ON THE CAUSE

OF ANOMALOUS DETERMINATIONS

OF TIME

by

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"On the Cause of Anomalous Determinations of Time".

The precise determination of time requires for its execution, a series of scientific instruments which pos:sess the same fundamental character, but may vary in pattern and design, in different observatories. As we shall, in this paper, be referring to these instruments, an introductory brief account of those used at the Royal Observatory, Edinburgh, will make our references clear.

I. Transit Circle. - This instrument was erected in 1896 on granite piers, resting on a platform of solid rock; it is housed in a building west of the main office and sep:arated from it by a long corridor. The walls of the transit house are made of a double sheet of corrugated iron with an air space between them.

The diameter of the object glass is 8.5 inches, and its focal length 8 feet 11 inches. The axis of rotation is 4 feet 7 inches long. It is surrounded near the piv:ots by two steel rings containing ball bearings, and these hang by short chains from strong springs attached to iron castings resting on the piers; the springs can be lengthened or shortened until they bear the necessary proportion of the instrument's weight.

The declination circles are 3 feet in diameter and each distant 23 inches from the axis of the telescope; the graduations are made on a band of silver let into the circles and are at 5' intervals. Eight microscopes strongly clamped on a cylindrical frame are provided for reading the zenithal distance.

The /

The transits are recorded by means of the travell-:ing wire of an impersonal micrometer, operated by hand, and which in the present arrangement makes one contact during each revolution; in the case of a polar star a hand tapper is used. There is a special device, at the micrometer head, which allows it to miss one contact, when the travelling wire coincides with an imaginary mid-:dle wire to which all observations are reduced.

Two collimators situated north and south of the Transit Circle are carried on granite piers with object glass 5" aperture, and focal length about 76". The iron supports are designed with sufficient height and are pierced with apertures to permit the Transit Circle to be pointed, so as to look through them; if the cell of an object glass were fitted in one of these apertures, and an azimuth mark provided at the focus of this lens, then we should be able to observe terrestrial azimuth upon Sir David Gill's plan. (See the Observatory No.459 and more fully "History of the Cape Observatory"p.38). How-:ever, owing to the difficulties of making permanent marks in the rocks, and provision of lenses of very long focus, this plan has not been carried out; and the col-:limatorsthemselves are taken as azimuth mark. There are a series of thermometers in the transit house attach-:ed to the piers of the collimators and the T.C., but the temperature recordsreferred to in this paper are those of the eastern pier of the transit circle only, and are sometimes referred to as the superficial tempera-:tures.

The clocks are situated in the basement, at the eastern end of the main building. They are housed in small cells adjacent to each other, and are kept in constant temperature and pressure. This is secured by means of a heater relay, a mercury thermometer and a fan. As the mercury rises it establishes an electric-:al contact, and the current passing through excites the magnet of the mechanical relay, which in pulling down the armature breaks an electrical circuit, and throws the re-:sistance of the fan and the heater in series, thus op-:erating the fan. When the mercury drops, the broken circuit is re-established, the current passing short cir-:cuits the fan, and is thus increased in its passage through the heater. The clocks are enclosed in an air tight case, which may be exhausted to any desired pressure.

The clocks, which will be referred to, are:- Leroy 1230, Riefler 258, Shortt No.0 and Shortt No.4. The last two are designed by Mr W. H. Shortt, M.I.C.E., and mark a considerable advance in modern Horology. The principle of these clocks is that the master pendulum swings entirely free, except every 30 seconds, when an impulse is given by a small gravity jewel piece to a small brass wheel attached to the pendulum, the release is made by the slave clock. As soon as the impulse arm is clear, it proceeds to close a resetting piece, and the current so passing is in series with an electro-magnet (synchroniser) in the slave clock, to whose armature is attached a small projecting tongue, which engages a vertical springing piece attached to the slave pendulum as /

as it passes through its mid-position. The hit and miss action of the synchroniser is the control provid:ed by the free pendulum on the slave. The clocks will be referred to as SH.O and SH.4. (See Dictionary of Applied Physics. Professor R.A.Sampson, F.R.S., Clocks and Time-Keeping)

Leroy 1230.- This clock is identical with No.1229 which has been for some years the directrice of the clocks of the Bureau international de l'heure at the Observatory of Paris. The impulse is provided by the energy of a bent spring.- (See Msr. Bigourdan's description of this clock and of Riefler, in Bulletin Astronomique Tome II, III Serie II page 378-408 and 265-329). This clock will be referred to as L.

Riefler 258.- This is the standard mean time clock at the Observatory, and is of the well-known Riefler first grade pattern. The maintenance is provided by the ener:gy of the suspension springs, but unlike other clocks this suspension is not fixed, but attached for support to a cock plate which rests by knife edges on agate pieces and thus can be rocked through small measured angles in the plane of motion of the pendulum. (See above refer:ence to "Bulletin Astronomique") The winding is pro:vided by a small heavy weight which as it gradually falls down, reaches finally the armature of an electro-magnet, which is thus excited and resets the moving weight. This clock will be referred to as R.258.

Studies with regard to the theory of maintenance in these clocks, and their comparative behaviour, have been published /

published by Professor R.A.Sampson, F.R.S., in a series of papers to the Royal Society of Edinburgh (Vol.XXXVII, Part I & II 1917-1918 and Vol.XLIV Part I 1922-24.)

Chronograph.- This is of Fuess type, and has been modi- :fied at the Observatory; it consists at present of 3 electro-magnets with their armatures, each hinged at their middle point; at the other end of the armature a steel pin is attached; a little above the pin in the pos- :ition of rest, a tape rolled on a cylindrical drum is driven by a clockwork arrangement. When a current ex- :cites any of these magnets, the armature is pulled down, and the pin marks a point on the tape;a short spiral spring brings the armature back to rest.

The outer pin records the stellar and the signals from Sh.0 and Sh.4, the middle pin records the signal from L. and the inner pin the signal from R. The start- :er operates at the same time the middle pin. This will be referred to as FX.

Microchronograph.- Its principle is that of an Einthoven galvanometer. The apparatus consists of a powerful electro-magnet, and between its poles a loop of platinoid wire forms the detector. The electrical signals of the clocks, after passing through suitable resistances are made to pass through the detector, which is thus deflect- :ed when the field is on. A mirror carried by the de- :tector receives an incident beam of light, after its passage through a vertical slit, and the reflected beam is focussed by means of a suitable lens, on a moving film inside a camera fitted with a cylindrical lens. As the uniformity /

uniformity of motion of the film cannot be trusted for more than few tenths of a second, an interrupter occults the slit and reduces the interval to 1/10th sec. or a "Decim." Any signal falling in this interval can be measured on the developed film, by means of a measuring machine to the nearest 1/100th of a decim. or 1/1000th of a second. By adjusting the various resistances in the leads from the different clocks, each signal can be recog-:nised.

We refer to Professor R. A. Sampson's paper in M.N. June 1918 "On the Measurement of Time to a Thousandth of a Second".

The advantage of the microchronograph is that it provides a simple way of registering a signal without any lag whatever between the time of emission and that of registration. It will be seen later how this provides a check on FX. This apparatus will be referred to as MX.

The object of this paper is the following:-

To give additional evidence in favour of a method of time reduction that eliminates the instrumental level error^{l}. This method has been given by Professor R. A. Sampson, F.R.S in (M.N.85,1925) and was applied to derive the clock error of Sh.4 during 1924. The error of Riefler 258 will be considered here, and a series of observations extending from 1915-1923 will be used.

To show that the ordinary method of time reduction introduces large erratics, which are removed in certain cases modified in others and generally reduced, when the reduction is car-:ried without L

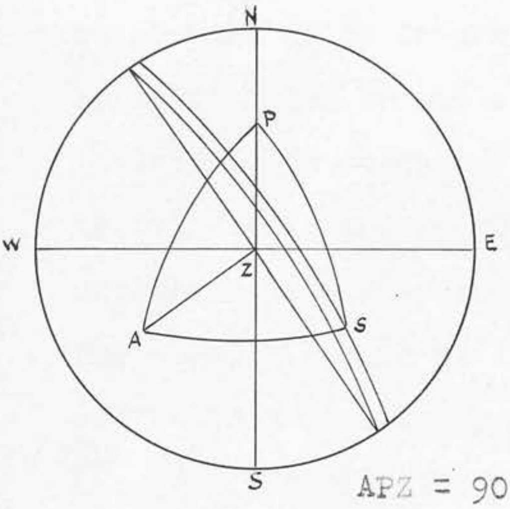
That there are seasonal errors introduced in the time determination /

determination as obtained by Mayer's formula.
Finally, in an attempt to assign the theoretical and practical causes that contribute to anomalous time de-:termination.

The final and ultimate reference to our standard time is in reality the measurement of the uniform angul-:ar rotation of the earth by the Transit Circle observa-:tions. This is however attended by many serious dif-:ficulties, such as the climatic condition limiting the number of clear nights, and the much more important prob-:lem of the instrumental constants; the latter are well illustrated in text books. We shall very briefly der-:ive the formula used for the reduction and indicate the procedure adopted here.

The instrumental constants are:- the collimation error C, i.e., the deviation of the axis of the telescope from true perpendicularity to the axis of rotation; the level error l, i.e., the relative displacement of the noles of the declination circles, and thirdly, the azimuth error, 90 + a of one of the noles.

Let W.E.S.N. be the plane of the horizon and let AZ represent the vertical plane where the axis of rota-:tion lies. A the western nole, and S a star crossing the spider threads in the eye piece. As the telescope revolves the sight line describes a small circle whose distance from the collimator axis is C and is the collima-:tion error.



Let $90 - m$ = hour angle of pole A

$90 + a$ = azimuth Do.

l = altitude Do.

n = declination Do.

ϕ = latitude of place

δ = declination of Star S

Then -

$APZ = 90 - m \quad ZP = 90 - \phi \quad AZ = 90 - l$

$AS = 90 + c$

$NZA = 90 + a \quad AP = 90 - n \quad PS = 90 - \delta$

In the spherical triangle PZA

$$\cos n \sin m = \sin l \cos\varphi + \cos l \sin\varphi \sin a$$

$$\cos n \cos m = \cos a \cos\varphi$$

$$\sin n = \sin l \sin\varphi - \cos l \cos\varphi \sin a$$

Also if τ is the hour angle of the star east of the meridian, then $APS = 90 - m + \tau$, and in the triangle APS we have

$$-\sin c = \sin n \sin\delta - \cos n \cos\delta \sin(\tau - m)$$

The quantities a, l, c, can be made very small, and also m, n, τ, and thus only terms of the 1st order will be retained; the above formula is thus reduced to

$$\tau = m + n \tan\delta + c' \sec\delta \qquad \text{(Bessel's formula)}$$

Notice also that the declination of the western pole and the complement of its hour angle are connected to a, l ths.

$$n = l \sin\varphi - a \cos\varphi \qquad m = l \cos\varphi + a \sin\varphi$$

Substituting these values of m, n in Bessel's for-:mula we obtain Mayer's formula.

$$\tau = a \sin(\varphi - \delta)\sec\delta + l \cos(\varphi - \delta)\sec\delta + c \sec\delta$$

The procedure adopted at the Royal Observatory, Edinburgh /

Edinburgh, is to determine first the collimation line by setting the moveable wire of the North collimator five times in contact right and left with the image of the vertical wire in the South collimator which remains untouched; the reading obtained is referred to as N/S. The transit circle moving wire is then set on the North and South collimator and the readings are referred to as $\frac{TC}{N}$, $\frac{T.C}{S}$; finally the level reading is obtained from co-:incidences of the moveable wire of the telescope with its image by means of a mercury bath and a Bohnenberger eye piece. These quantities are scheduled thus:-

$$C = \text{Constant} - \tfrac{1}{2}\left(\frac{TC}{N} + \frac{TC}{S}\right) = \text{collimation error}$$

$$l = L \qquad - \tfrac{1}{2}\left(\frac{TC}{N} + \frac{TC}{S}\right) = \text{Level} \quad ''$$

$$A = \text{Constant} + \tfrac{1}{2}\left(\frac{TC}{N} - \frac{TC}{S}\right) = \text{Azimuth of the T.C. east of the south collimator.}$$

$$(\alpha) = \text{constant} - \frac{N}{S} = \text{Azimuth of the North collimator east of the south collimator.}$$

They are converted into seconds of time by the fac-:tor 1^r = 1.313 sec. which remained unchanged until 1924; when a new micrometer necessitated a re-determina-:tion of a new factor 1^r=3.26 sec. while that of (α) = 1.824 sec.

We may remark before proceeding further that C has to be corrected for diurnal aberration which amounts to .021 $\cos\varphi \sec\delta$, when the star is on the meridian; this is about .004 sec. for Edinburgh. The quantities A, (α) and the temperature were observed though they are not actually necessary to the reduction; it will be seen later /

later how such observations became useful. The stel-
:lar azimuth a was derived from observations on two polars, preferably one above and one below pole. The departure of the observed R.A. of a star from its tab-
:ular R.A. is the clock error. Ten time stars are usually observed in order to determine this clock cor-
:rection.

If the clock error so determined be plotted on a time basis it will be readily seen that their variation from day to day is far from being uniform; on the con-
:trary they provide a series of irregularities which it will be our aim to trace to their sources. But be-
:fore doing so, consider the necessary steps taken in order to register and reduce a stellar observation, as each step constituting a measurement of some kind will naturally include a small error. The observer deter-
:mines for each set of time determination the errors C and l, but as the former is of slow variation he makes a single set of observations of this quantity. The case is otherwise with the level error. It varies sensibly with the temperature and very closely follows it (MN 1914 75 vol No.2); he determines the value at the begin-
:ning and at the end of each time observation. The mean is taken for purpose of reduction. During a stellar transit, the micrometer head is turned careful-
:ly so that the travelling wire continually bisects the star during its transit in the field of view, but atmos-
:pheric refraction produces sometimes a blurred and an unsteady image of the stars, thereby introducing an error /

error of bisection. The rotation of the micrometer head provides a series of contacts, giving rise to electrical current in one of the magnets of FX and thus actuating the pricker attached to its armature to mark a point on the moving tape; any variation of lag result-:ing from inertia of the moving pieces is an erratic feature debited wrongly to the clock error. Also the electrical signal from the clock is too weak to operate FX directly, it has first to pass through a Post Office relay, introducing thus another electro-magnet, with an armature starting from rest;the secondary current oper-:ates another electro-magnet in FX, and is open to the same objection as the first. Finally when the mean time clock R is compared with the Director it has beside those mentioned, errors of its own. In (M.N.8 1918 June) Professor R.A.Sampson has shewn that there are inequalities in the teeth of the scape-wheel, which de-:termine the time signal; these inequalities can be measured by M.X and are in fact taken into account when calculating the comparative error with another clock.

We see from this the number of links leading to a time determination or an inter-comparison of clocks; any one of these links may be called the time, but the problem of fundamental importance to us is the varying lag between them. This can be ascertained by compar-:ing the results of comparison of the clocks by FX and MX, as the latter has no moving pieces of armature, a signal is instantly registered as soon as it passes through the detector, consequently there is no lag anywhere /

anywhere, and the records are measured to 1/1000 and rounded to 1/100 of a second. It provides a check on FX and as this is done daily, any variable lag of the moving pieces is immediately detected and brought to a point of order that could hardly affect our calculations. The conclusion from this is that these irregularities in the clock trace could not be ascribed to the chronographic system.

The name of erratics has been given to these irregul-:arities; they are in reality the departures or residuals of a number of transit circle observations of the clock error, from an adopted rate embracing the whole of this group. Also owing to the fact that the comparison of two clocks by means of MX when plotted on a time basis (M.N85,1925) shows no sign of irregularities, we conclude that the erratics are not due to actual diurnal fluctu-:ations in the rate of the clocks. Furthermore by com-:paring the detailed features of the instrumental constants with the trace of the clock error, it becomes perfectly clear that changes in m eliminate themselves very imper-:fectly from the trace of the clock error. (MN. 3.922)

Thus the erratics could neither be ascribed to the regular going of modern astronomical clocks nor to the existing chronographic system, but are, as a rule, due to -

(1) The determination of the instrumental constants

(2) Any systematic errors in R. A. of stars

(3) Anomalous atmospheric refractions

(4) Accidental errors

(5) /

(5) Personality of observers

We shall consider here the instrumental constants only, and in particular the level error.

These conclusions have been derived by Professor R. A. Sampson in the above mentioned papers. He also derived a formula by which the level error is dispensed with altogether, and the quantity A used instead.

It is easy to see how this can be achieved; from the relations found elsewhere, we have

$$n = l \sin\varphi - a\cos\varphi \qquad \text{or} \qquad a = l\tan\varphi - n\sec\varphi$$

$$m = l\cos\varphi + a\sin\varphi \qquad\qquad m = a\,\mathrm{cosec}\,\varphi + n\cot\varphi$$

If to the quantity m we add (A - a) $\mathrm{Cosec}\,\varphi$ we elim-:inate a and with it the level error l from the formula

$$\tau = m + n\tan\delta + c'\sec\delta$$

and the new clock error as determined without l is τ - (A - a) $\mathrm{cosec}\,\varphi$. In this way we eliminate all faults in l, but we introduce instead the faults due to A, which, as will be seen, are much less detrimental to the clock error than those of l.

This was applied to a series of observations extend-:ing from January 1915 to December 1923; the clock error was first determined in the usual way by Mayer's formula. It was then plotted on a time basis, as shewn in the attached plates, and the erratics derived. The method was to adopt a straight line that will fit a group of observations, as closely as possible; the departure of a single observation from this adopted rate is the errat-:ic = observed clock error - Plotted clock error.

The assumptions made here is that the clock actually runs with a uniform constant rate for a certain time and when /

when any changes occur, either in temperature or pres-:sure inside the casing of the clock, or any microscopic displacement of the knife edges of the cock plate in R, on the agate pieces, this constant rate is replaced by another constant rate. The adoption of this course leads to a uniform treatment of the whole series of ob-:servations, for even the most simple parabolic curve would tend to introduce variations as we pass from one group to the other. Similarly we derive the clock error without using the level l as obtained from the above formula. This is plotted on a time basis, the plotted error marked; the difference gives the erratic - without l.

The comparison of the two sets of erratics (table I) shews at once that many of the erratics resulting from the ordinary method of reduction, are eliminated, some are only reduced, finally the reduction with A introduc-:es elsewhere erratics smaller in number and in varia-:tion. A glance at the plates will shew the distinct improvement resulting in a smoother curve for the clock errors. For the purpose of giving more details I have selected a number of erratics during each year, as shewn in table II., in order to form a numerical estimate of the difference eliminated. The best erratics for com-:parison are those found in a moderate rate of the clock; the pressure inside the case has to be altered in order to keep the going of the clock within certain limits, namely $\pm$ .50 sec. The monthly, yearly and general mean of the two sets of erratics were formed, and scheduled in /

in table III.; it will be seen that the general mean is reduced from $\pm$ .03 to $\pm$ .02; this is a large reduct:ion, for the latter value includes all errors due to personality and those of accidental nature, pertaining to the instrumental constants, the chronographic system and errors due to atmospheric refractions, and those in systematic errors in the R. A. of stars; but apart from this general reduction, the aim was to show that certain of large erratics introduced in the ordinary method have been eliminated. The azimuth A of the transit circle east of the south collimator has been derived from an arbitrary zero (.397) and thus the clock error derived by using A is not an absolute error; however we are more concerned with the variations of the clock error than of their absolute values; and the fixing of the datum line of these errors has no effect on the outcome.

We now pass to the more difficult point of seasonal variations. These have been formed by taking the dif:ference between plotted error as obtained from the re:duction with 1 and the plotted error from the reduction with A; if this difference is nil everywhere or constant throughout the 9 years of observations considered, then there is no systematic error introduced at all; on the other hand if such a difference shews a seasonal varia:tion a systematic error must have been introduced, - in either or both methods of reduction. Table III shews the monthly mean for every year; these have maxima and minima, only it appears that they do not exactly occur at the same time, but undergo a slight shift from year /

year to year. By taking the mean for every month we obtain the variation in a mean year. The curve attach-:ed shews that there is a seasonal variation, the low-:est value occurs in April, and the highest value in November; the difference between the two is .078 sec. - it is difficult to trace the cause of this discrepancy. Is it due to the eliminated level error l or to the introduced quan-:tity A? - There is no doubt there is a seasonal variation in both l and A. However the south collimator appears to be fairly steady (M.N. 75 1914) whereas the level error varies sensibly from night to night, and also shows a wider seasonal variation following the superficial tem-:perature; but since the reduction with A has given a decided improvement in the trace of the clock errors, it appears a probable presumption that the level error l introduces seasonal variations in the plotted error, which are greater than those introduced by the reduction with A.

Also Professor R. A. Sampson has shown in M.N.82 page 219, that the comparison of wireless signals from Annapolis with the mean of six observatories shews a de-:cided seasonal error in the time reduction of Washington with the level, and in M.N. 6 page 567, the comparison between Edinburgh and Annapolis shews an improvement of this seasonal error when the reduction is carried out with A and n instead of l.

It is a difficult problem to know exactly why the level error is responsible for the erratics mentioned, for in the time reduction it appears to be theoretically eliminated /

eliminated by the Mayer's formula. Actually this elim-:ination is imperfect, and the instrumental constants reappear, specially the level error in the trace of the clock correction. It may be that a certain theoretical error is introduced tacitly in the value of l which es-:capes detection.

With this object in view, we now give a discussion on the possible theoretical errors that find their way into the value of l.

The level error is determined by means of a mercury bath and a Bohnenberger eye piece; the moveable wire of the telescope is made to coincide with the reflected image of the middle wire, and the reading of the micro-:meter gives a measure of the level error, if the collim-:ation error was nil. This reading is taken at the be-:ginning and at the end of each observation, but as the mercury trough has to be removed during the observation, the two readings form two independent determinations of the level error. They differ very slightly, for they both depend on the temperature which varies slowly and uniformly during the observing period; and this fact rules out of court any accidental errors in the determin-:ation of l without affecting the theoretical errors.

The mean of the two sets of readings is taken for the purpose of reduction. The level error gives us in reality the inclination of the axis of rotation to the horizontal, or say the relative vertical displacement of the western nole with respect to the eastern nole of the declination circle. If the level error be denoted /

denoted by l, it means that vertical axis of the tele-:scope makes an angle l with the direction of gravity at that instant.

Imagine a mercury bath totally unaffected by the tidal actions of sun and moon, or any meteorological changes that may occur during the observation, and also suppose that the earth's crust is perfectly rigid, un-:affected by the above mentioned or any other causes. Then in this case the level reading l as obtained from such a mercury bath, will give the true relative dis-:placement of one of the poles with respect to the other, and when used in the Mayer's formula is totally elimina-:ted in the determination of the clock error.

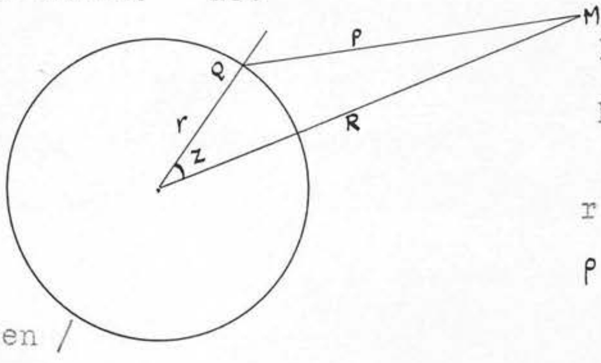
In point of fact, every horizontal surface is under-:going a series of oscillations, small indeed, but meas-:ureable, and the direction of gravity being the normal to such a surface, is changing constantly; and as we are measuring the inclination of a vertical axis of an instru-:ment resting on the earth's surface from the normal to a mercury bath, some sort of assumptions must be made, as to the nature of the earth's crust, before we can de-:cide that the error we are measuring is really due to a tilt in the axis of rotation, or simply due to a tilt in the mercury surface, relative to the earth's crust. These assumptions are the following:-

(1) That the earth's crust is perfectly plastic and be-:haves actually as if it was covered with some fluid; i.e., we have the theoretical surface of the geoid. We imagine the T.C. to be floating on this ocean; then the /

the measurement of l will be the true level error of the instrument itself; we remain unaware of any differential attraction due to the sun or the moon; in as much as man in the mid-ocean is unaware of the tidal effect of our satellite - we only know of the existence of this effect by reference to something apparently fixed; in this case it is due to the solid crust of the earth that we notice these effects. It must be that either this crust is absolutely rigid or not deformed to the same extent, and in either case our first assumption is rendered invalid.

(2) If the earth's crust is perfectly rigid, then when we measure the level error we are tacitly introducing a small error which will reappear in the clock error. To be more precise, we are measuring the inclination of the vertical axis of the telescope set on a perfectly rigid earth from a changing datum line, namely the normal to the bath of mercury. It is then evident that the quantity by which this normal varies is tacitly debited to the level error; and the latter is therefore affected by a variable error δl_g , which will reappear in the clock error as an erratic feature $\delta l_g \sec\varphi$. Before proceeding any further, we shall make an attempt to derive the value of δl_g on the assumption of a perfectly rigid, homogenous and spherical earth.

Consider the differential attraction of the moon on the earth. Let



M = mass of moon

R = distance from centre of earth to the moon

r = earth's radius

ρ = distance from a point Q on the earth's surface to M

Then /

Then the potential at Q

$$V = G\frac{M}{\rho} = G\frac{M}{R}\left\{1+\frac{r^2-2Rr\cos z}{R^2}\right\}^{-\frac{1}{2}}$$
$$= G\frac{M}{R} + G\frac{M}{R^2}\, r\cos z + G\frac{M}{R^3}\, r^2\left(\frac{3\cos^2 z-1}{2}\right) + \dots$$

The moon's tide generating potential at Q is therefore the spherical harmonic

$$G\frac{M}{R^3}\cdot r^2\cdot\frac{(3\cos^2 z-1)}{2}$$

and by differentiating this expression with respect to r and with respect to (r.z) we obtain the vertical and horizontal component of tide generating force, thus:-

$$F_v = \frac{GM}{R^3}\; r\;(3\cos^2 z - 1)$$
$$F_h = -\frac{3}{2}\;\frac{GM}{R^3}\; r\sin 2z$$

Then the 1st force F_V tends to alter the gravity at Q and the second force deviates its direction; these forces calculated in fraction of $g = \frac{GM'}{\rho^2}$

become (M' mass of earth)

$$\frac{M}{M'}\left(\frac{r}{R}\right)^3(3\cos^2 z-1)$$

and

$$3/2\;\frac{M}{M'}\left(\frac{r}{R}\right)^3\sin 2z$$

Now $\frac{M}{M'} = 1/82$ $\frac{r}{R} = \frac{1}{60}$ approx.

$$\left(\frac{M}{M^1}\right) \times \left(\frac{r}{R}\right)^3 = \frac{1}{17.700.000} \quad \text{say} \quad \frac{1}{18.000.000} \quad \text{Approx.}$$

Thus the change in the value of gravity becomes negligible but the deviation is in seconds of arc

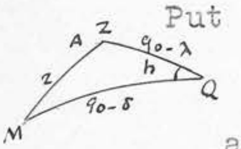
$$\frac{3}{2} \times \frac{1}{18.000.000} \times \frac{\sin 2z}{\sin 1''} = .018''\sin 2z$$

The sun's effect, owing to its remote distance and greater mass is about $\frac{1}{2.18}$ times the moon's effect, i.e., it is .008" sin 2z and will be additive when the moon is in conjunction or in opposition, and subtracted when it is in quadratures. Further if A be the azimuth of the moon /

moon the component of the deviation δ above on a line E - W and N - S

$$x = \delta \sin A \qquad y = \delta \cos A$$

Then from the moon zenith distance and hour angle we can express x, y in fractions of the latitude of the place, hour angle, and declination of the moon.



Put .018" = α then

$$x = \alpha \sin A \sin 2z. \quad y = \alpha \cos A \sin 2z.$$

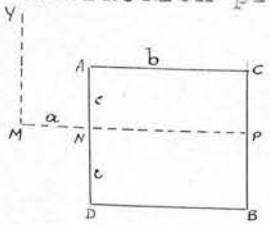
and from the ordinary formulae of the spheri:cal triangles MQZ we get

$$x = \alpha \sin\lambda \sin 2\delta \sin h + \alpha \cos\lambda \cos^2\delta \cos 2h$$

$$y = \frac{\alpha}{2} \sin 2\lambda (1 - 3\sin^2\delta) - \alpha \cos^2\lambda \sin 2\delta \cos h + \frac{\alpha}{2} \cos^2\delta \sin 2\lambda \cos 2h$$

The foot of the vertical line therefore describes daily and semi-daily ellipses. But it has often been pointed out that the rising tide may produce on a plumb line near the coast a deviation that may be as great, if not greater, than that due to direct action of the moon or sun.

This problem has been worked by Lord Kelvin (Natur:al Philosophy Part 2 Article 818); on the assumption of a rigid incompressible earth, Sir George Darwin in a report to the B. A. in 1882 worked out the deviation by giving a rigidity to the earth as much as that of steel. In the assumption of a rigid, incompressible earth, the attraction produced by a parallelepiped of water on the plumb line can be easily obtained (Nat:ural Philosophy part 2 page 390).



$$X = 2 G \rho h \log \frac{\tan \frac{1}{2}\theta_c}{\tan \frac{1}{2}\theta_d}$$

Where θ_c and θ_d are the angles made by MD and MC with MY now let MN = a. AN = NP = c then

$$X = 2 G \rho h \log . \left(\frac{a+b}{a} \cdot \frac{r+c}{s+c} \right)$$

where /

where r = A M   s = B M h = height of water
the deviation is

$$\frac{\lambda}{g \sin 1''} = \frac{3}{2\pi \sin 1''} \frac{h}{5.56} \frac{1}{R} \log . \frac{a+b}{a} . \frac{r+c}{s+c}$$

Let AC = AN = 50 miles = c = b, and let a = 1 mile, h = 10 feet, then the deviation is .032"; if a = 2 miles the deviation .025", and a = .10 miles the devi:ation is .050". Without going into any other details, these figures shew that for an observatory near the coast the deviation produced by the tide itself may be as great as that due to the direct attraction of the tide generating body.

We see from these considerations that the highest value of the deviation of the vertical due to the act:ion of sun and moon and any effect of rising tide cannot be more than .050" which would be responsible for an er:ratic whose greatest value is .006 sec. only a very small and almost negligible quantity.

(3) In reality however the earth's crust is neither fluid nor perfectly rigid and incompressible, and it suffers to a certain extent from the various tidal act:ions. In order to calculate the extent of the deform:ations we require to know the rigidity of the earth; this in itself is a large question, and is altogether beyond the scope of this paper; there is not only one rigidity, but many, as the earth's body is far from being homogenous.

Lord Kelvin has shewn if the rigidity of the earth was like that of glass, the oceanic tides would be 2/5 of their theoretical amount, and if the rigidity be that of steel, they would be reduced to 2/3. Professor Love in /

in his book on "Some Problems of Geodyamics", page 49, applies an equilibrium theory to the earth's crust, and he finds that on this theory the oceanic tides are diminished in consequence of the corporeal tides in the ratio $1 + k - h = 1$

Now from the observation of fortnightly tides, this ratio is about 2/3 x and $\therefore$

$$h - k = 1/3$$

Where h and k are two numbers defining the height of the earth tide at the surface, and the inequality of potential that is produced by the earth tide, the value of k can be found from a relation between the period of the earth's instantaneous axis of rotation, as determined by precession&the period observed owing to the fact that the earth is a deformable body.

$$k = \left(\frac{2ge}{a\omega^2} - 1 \right) \left(1 - \frac{\tau_0}{\tau}\right) = \frac{4}{15}$$

$\therefore$ h = 3/5, in other words the height of the earth's tide is 3/5 of the theoretical equilibrium value of the oceanic tide; and this result is arrived at without any hypothesis with regard to the rigidity of the earth; it means /

x Sir G. H. Darwin Scientific Papers Vol. I. p. 346.

W. Scheqayder "Ein Beitrag zur Bestimmung des Starr-:heitskoeffizienten der Erde". Beitrage zur Geophysik.

O. Hecker, "Beobachtungen an Horizontalpendeln". Veroff d. Konigl. preusz. geodat Inst. 1907.

means then that 2/5 of the value of luni-solar deflec-:tions of gravity is introduced right away into the value of 1, but this as has already been pointed out is a very small quantity. We conclude that errors intro-:duced into the instrumental correction $1 \sec\varphi$, which owe their source to the lunar or solar or tidal deflec-:tions of gravity are negligible.

There remains another source of error to be consid-:ered, and that is the variation with the temperature; it has been pointed out in M.N. 75 1914 that the level error follows very closely the superficial temperatures of the piers.

Now the deformation produced by the daily variat-:ions of temperature in the earth's crust, forming base to the granite piers, are different from the deformation produced on the mercury bath; and this differential ef-:fect produces an error in the estimation of the instru-:mental level 1. This can be made clear by following a closely similar argument as that followed in the case of the lunar deflections of gravity; for if a surface of mercury behaves in exactly similar manner, under the act-:ion of the sun's heat, as the basic rock, then the value of 1 as read from such an imaginary bath is inherent to the instrument, and is the value prescribed by Mayer's formula; actually the mercury bath behaves differently, and this difference is debited wrongly to the value of the level error.

The numerical value in seconds of arc of this er-:ratic quantity is very difficult if not impossible to arrive /

arrive at; but following a similar approximate course as the one adopted in the determination of the lunar deflection, we form an upper limit of this quantity. In this case our assumption is that the earth's crust remain insensible to temperature variations, but the act-:ual surface of mercury varies with the temperature. Then in this case the value of the level error contains an error δl_T , which is the variation of the direction of gravity due to temperature. Recent experiments on hori-:zontal pendulum and specially those of O. Hecker, carr-:ied at Potsdam[x] in 1907 have furnished us with numerical estimate of the daily variation of gravity due to the sun's heat, and to lunar and solar tidal actions as well. Hecker made his experiments with two horizontal pendulum crossed at right angles, and with equal azimuth, from the N. and S. line; on each pendulum a mirror reflects a ray of light on a photographic film moving by means of a clockwork arrangement; the two pendulums are kept at constant temperature in a cell 25^m below the ground sur-:face, and the curves obtained are subject to Harmonic Analysis in order to determine the law of the deviation of the vertical. In order to exhibit separately the variation of the vertical due to the temperature effect of the sun and its attraction as well, the deviation at the hours 0 - 12, 1 - 13, 2 - 14, &c., at 12 hour inter-:vals were read, and the half sum and the half dif-:ference formed; the first term gives the attraction ef-:fect as the thermal effect is eliminated being equal and of opposite sign at 12th interval; but the half second term /

X See previous reference & Lallemand Bull. Astr. page 369 Vol. XXVIII. 1911.

term gives the thermal effect and the tidal action is eliminated. In this manner Hecker obtained by taking a great number of observations, a harmonic curve of amplitude $\pm$ .013" for pendulum I and $\pm$ .018" for pendulum II. (Compare this with .008" due to direct attraction of the sun). This gives a deviation $\pm$ .025" along the meridian, which is .002 sec. of time and in:troduces an erratic feature in the time determination of .004 sec. - a very small quantity again even under our assumption of a perfectly insensible crust.

But the analysis here produced is due to the diur:nal variation of direction of gravity, and as the time determination is carried at approximately the same time at every night's observation, it would appear as a con:stant error and not an erratic feature. Moreover the values obtained from Hecker are the means of a great num:ber of observations, thus cutting out the abnormal vari:ation of temperature that invariably is associated with abnormal variation in the level.

It is not the mean diurnal deviation that is requir:ed, but the actual deviation at every night. But in any case such variation cannot be very far from the mean, and seeing how small is the error introduced by the diur:nal deviation, and under our present assumption, we may safely conclude that the error introduced by variation in temperature is very small also.

It appears from this discussion that there is no theoretical error in the value of 1 as determined by the process adopted here; or that these theoretical errors are /

are so very small that they could hardly account for the erratic features of the clock errors, and yet a great number of these erratics are smoothed away when the reduction is made without 1.

I venture to make a suggestion at this point, - and that is to have a surface of mercury permanently undis:turbed during a long period. If for instance, a deep recess could be made between the piers of the T.C., and a surface of mercury introduced there, and left undisturb:ed for a long time, this would provide a datum line, only affected by, or slightly by, tidal attraction or temperature variation, &c., which are all very small. In fact, this is a similar arrangement as the azimuth mark on Gill's plan.

There remains, however, a further point to be con:sidered: the value of the level error is determined when the axis of the telescope is vertical, and no stel:lar observation is taken in that position. The problem is to determine the level 1 for every position of the telescope; if these values of 1 vary then the pivots are not free from irregularities, but in this respect the azimuth and the collimation enter as well; the first is determined when the axis of the telescope is pointed to the North pole, the second when the axis is horizontal and neither of these three positions are used during the stellar observation; furthermore the deviation from the mean of a clock star is as much as .07 sec; it might be that the irregularities of the pivots are responsible for introducing large errors in the value of 1, and thus are/

are responsible for a great number of erratics.

Mr H. Knox-Shaw (Helwan Bulletin No.31) has shown that there is a correlation between the erratics in his clock errors and the level error as determined from a striding level; apart from error of division, a possible source of error was due to the deposition of fine sand on the axis of the instrument, thus causing irregularities in the pivot.

However, the pivots of the T.C. here were examined at Dun Echt, and again in February 1906. The errors due to any irregularities in the pivots were found to be negligible. (See Annals of the Royal Observatory Edinburgh Vol. III. p. V.)

In conclusion, we may mention that various writers have attempted an explanation of the erratic jump in the clock corrections in terms of the varying atmospheric refraction without any decisive result. A steep barometric gradient introduces a tilt in the air strata, thus causing a continuous change of the geographical zenith, and thus altering the R.A. of the star by the lateral component of refraction; this will introduce an erratic in the clock correction (M.N. 82 page 219); but beside this, there is a refraction effect in the transit house, due to a temperature gradient which will also introduce an erratic quantity. These doubtless contribute to the erratics, but it is difficult to assign their proper values.

Explanatory note of tables and diagrams

Table I. shews the transit circle observations of the clock errors of Riefler 258 from Jan. 1915 to Dec. 1923. The clock errors are first calculated by the ordinary Mayer's formula and then by a method proposed by Prof. R. A. Sampson, which elimina the level error l and introduces the azimuth quantity A. The adopted or plotted clock errors in both methods of reductio are also shewn.

DIAGRAMS :- These, represent the behaviour of R 258. The abscissaes are the dates to a scale of 1" = 20 days, and the ordinates are the clock errors to a scale 1" = 1 second. There are 2 sets of diagrams for each year. The first set is represe ed by a full and a dotted line shewing respectively the clock errors reduced by the usual Mayer's formula and the adopted clo error. The second set is also represented by a full and a dott line; the clock errors reduced by the method proposed by Prof. R. A. Sampson, and the adopted clock error in this case.

Table II. - Represents a summary of results where the prominent cases, as shewn in the diagrams by small circles around them, have been fully studied. There is a table shewing the monthly mean erratics which occur in both methods of reduction.

Lastly in the table of systematic errors; the mean difference between the plotted errors in both methods of reduction are she for every month. A diagram attached to this table shews the variation of this monthly mean in a year representing the mean the nine selected years.

Systematic Errors

Table III

	Jan	Feb	March	April	May	June	July	Aug.
1915	.07	.09	.11	.08	.09	.17	.12	.16
16				.05	.12	.14	.10	.08
17	.05		.03	.09	.03	.10	.14	.07
18	.17	.05		.01	.03	.03	.02	.02
19	.09		.10	.03	.07	.13	.01	.11
20	.08	.16	.11	.07	.11	.13	.03	.04
21	.05	.00	.04	.02	.03	.04	.05	.06
22			.03	.02	.06	.11	.07	.05
23	.05	.04	.07	.09	.16.			.15
	.080	.073	.070	.051	.078	.106	.068	.082

	Sept	Oct	Nov.	Dec	MEAN
1915	.21	.27	.29	.16	.152
16	.12	.08	.07	.03	.079
17	.09	.04		.14	.078
18	.04	.02	.11	.13	.060
19		.15	.16	.12.	.097
20	.10	.06	.06	.08	.087
21	.11	.11	.13	.02	.055
22	.10	.10	.10	.06	.070
23	~~.20~~ .16	.20	.24	.24	.140
	.117	.110	.129	.120	

MONTHLY MEAN ERRATICS IN BOTH METHODS

TABLE III

	1915				1916				1917				1918			
Jan	.05	.05	.03	.02					.03	.03	.00	.00	.01	.03	.02	.02
Feb	.05	.02	.04	.03												
March	~~.04~~ .03	.03	.01	.03					.05	.01	.02	.02				
April	.02	.02	.02	.03	.04	.03	.03	.03	.06	.03	.04	.02	.03	.02	.00	.01
May	.04	.03	.02	.02	.04	.04	.05	.03	.06	.01	.01	.03	.02	.07	.02	.02
June	.02	.02	.03	.02	.04	.04	.01	.02	.04	.03	.02	.04	.03	.04	.04	.01
July	.02	.02	.03	.02	.02	.02	.01	.03	.02	.03	.01	.01	.03	.04	.04	.06
Aug.	.03	.01	.02	.01	.01	.00	.00	.00	0	.04	.0	.02	.04	.03	.03	.03
Sept.	.01	.02	.02	.02	.04	.02	.01	.00	.03	.03	.00	.02	.03	.08	.02	.03
Oct	.03	.04	.02	.02	.04	.04	.04	.01	.05	.01	.01	.00	.05	.01	.02	.01
Nov.	.02	.03	.03	.04	.04	.07	.02	.03					.03	.06	.07	.06
Dec.	.03	.00	.01	.01	.02	.01	.03	.01	.05	.03	.02	.05	.02	.07	.01	.03
	.029	.024	.023	.023	.032	.030	.022	.018	.029	.025	.013	.021	.029	.040	.027	.028

	1919				1920				1921				1922			
Jan	.05	.03	.01	.00	.04	.04	.02	.03	.04	.05	.02	.03				
Feb	~~.04~~	~~.00~~			.05	.07	.07	.08	.03	.03	.03	.02				
Mar	.02	.03	.04	.02	.03	.05	.04	.03	.05	.03	.01	.03	.02	.04	.03	.02
April	.02	.04	.02	.00	.07	.04	.01	.04	.02	.03	.02	.04	.03	.05	.02	.03
May	.02	.06	.01	.01	.02	.07	.07	.03	.06	.02	.02	.02	.02	.02	.01	.02
June	.03	.04	.02	.02	.05	.05	.03	.03	.03	.03	.02	.04	.03	.03	.03	.03
July	.02	.02	.05	.01	.05	.04	.01	.01	.04	.03	.02	.01	.04	.03	.02	.03
Aug.	.04	.07	.02	.02	.03	.02	.01	.00	.02	.03	.02	.01	.03	.04	.02	.02
Sept					.03	.02	.00	.01	.03	.02	.01	.02	.06	.05	.01	.01
Oct	.04	.05	.02	.02	.03	.04	.09	.03	.03	.03	.01	.03	.03	.02	.05	.02
Nov.	.02	0	.03	.0	.09	.09	.05	.04	.04	.04	.05	.04	.03	.02	.02	.04
Dec.	.03	.04	.02	.02	.03	.04	.01	.02	.03	.05	.03	.04	.01	.04	.02	.04
	.029	.038	.024	.012	.039	.042	.028	.029	.035	.033	.022	.020	.030	.034	.023	.026

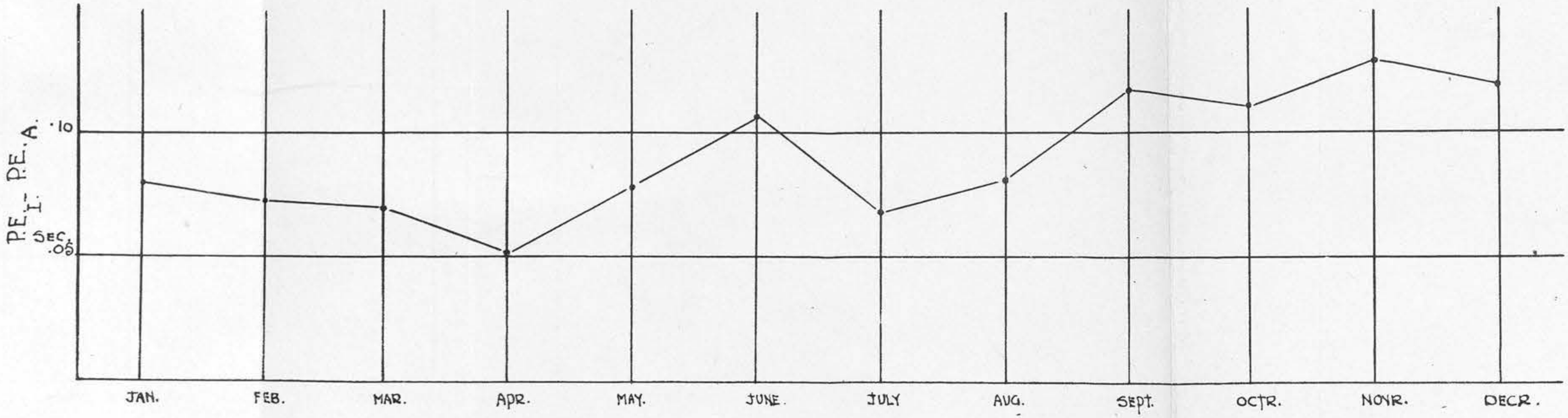
	1923								
Jan	.03	.03	.02	.02	Oct	.03	.04	.01	.02
Feb	.07	.04	.02	.02	Nov	.04	.05	.02	.03
Mar	.02	.03	.02	.01	Dec	.04	.02	.03	.01
April	.03	.04	.03	.01					
May	.04	.02	.05	.02		.039	.033	.023	.017
June									
July									
Aug	.02	.02	.01	.01					
Sep.	.07	.04	.02	.02					

GENERAL MEAN

.032 .033 .022 .022

with C. with A.

∴ ±.033 ±.022



P.E.I. – P.E.A.
SEC.
·10
·05
JAN.
FEB.
MAR.
APR.
MAY.
JUNE.
JULY
AUG.
SEPT.
OCTR.
NOVR.
DECR.

TABLE II.

Column

1. - Date.
2. - Erratic with 1.
3. - Erratic with A.

4,5,6- l, n, a.

7. - A - a.
8. - Range in clock corrections permitted by using extreme measures of l.
9. - Temperature.

SUMMARY OF RESULTS. Table II

1	2 Erratics l		3 A		4 l	5 m		6 a	7 $A-a$	8 Range from mean	9 Systematic error	Temp O.F
	sec		sec		sec	sec		sec	sec	sec	sec	
Jan 5	.03		.03		.26		.015	.41	.05		.07	
6	.03		.01		.26		.02	.41	.07		.06	
7	.11		.07		.25		.01	.38	.08		.06	
Jan 8	.08		.04		.27	.005		.39	.07		.06	
9		.08		.03	.25		.04	.44	.01		.06	
11	.02		0		.27	.02		.37	.07		.06	
Jan 14		.02		0	.29		.06	.53	.04	.009	.08	
15		.04		.03	.25		.05	.47	.06	.000	.08	
16	.06			0	.24		.06	.45	.11	.029	.07	
Jan 20		.08		0	.31		.07	.58	.01		.09	
21		.04		.03	.25		.08	.51	.07		.09	
22	.04		.03		.28		.02	.45	.08		.09	
Feb 22		.04		.03	.31		.001	.46	.07		.09	
23		.01		0	.27		.04	.47	.06		.08	
24	.02			.06	.27	.02	~~.02~~	.37	.14		.09	
25		.01		0	.31		.01	.47	.07		.09	
March 8	0		.01		.34	.01		.49	.08		.10	
9	.12		.04		.31	.02		.43	.14		.09	
12	.04			0	.38	.01		.54	.08		.06	
13	0			.01	.39	.02		.55	.06		.06	
VII 29		.10		.05	.35	~~.35~~	.003	.52	.05		.11	
30		.05		.05	.34	~~.34~~ .01		.48	.08		.10	
31		.03		0	.37	~~.37~~ .00		.54	.05		.09	
VIII April 15	.05		.04		.35	.03		.46	.10		.11	
16	0		.02		.37	.04		.48	.10		.12	
17	.01			.04	.31	.05		.38	.13		.12	

	Errors with l	Errors with A	l	n	a	A−a	Range from mean ±	Systematic error
IX May 10	.05	0	.38	.05	.47	.01		.06
12	.04	.05	.34	.07	.38	.06		.08
15	.03	.05	.29	.07	.30	.16		.11
17	.06	.02	.31	.04	.38	.11		.09
X May 20	.05	.01	.34	.02	.46	.08		.06
21	.10	.01	.37	.02	.57	.04	.04 .03	.04
22	0	.02	.38	.03	.50	.00		.02
XI June 12	~~.05~~ 0	.07	.34	.09	.39 ~~.45~~	.14	17	.17
14	.05	.06	.32 ~~.34~~	~~.05~~ .13	~~.41~~ .25	.13	13	.17
15	.03	.03	.33 ~~.313~~	.13 ~~.08~~	.25 ~~.40~~	.12	13	.17
XII July 28	.01	.04	.21	.06	.21	.13		.11
29	.07	.02	.24	.06	.26	.09		.12
30	.06	.05	.21	.05 (1)	.22	.16		.13
XIII Aug 10	.05	0	.25	.01	.35	.11		.15
12	0	.02	.22	.01	.34	.08		.13
13	.05	.01	.25	(1) .01	.38	.06		.13
XIV Sept 20	.06	.02	.22	.04	.24	.19		.19
21	0	.02	.21	.02	.28	.18		.19
22	.01	.01	.20	.01	.28	.18		.20
XV Sept 29	.06	.04	.13	(1) .01	.20	.21		.30
30	.03	.01	.16	.00	.22	.18		.26
Oct 1	.02	0	.15	.03 (1)	.17	.25		.29
XVI Oct 4	.05	.03	.18	.04	.20	.25		.28
5	.05	.02	.20	.05	.21	.25		.28
6	.01	.01	.18	.03	.21	.24		.29
7	.03	.01	.18	.03	.21	.25		.28

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

(1) Single polar star

XVII Oct. 26	.05	.07	.18	.03 (1)	.21	.23		.26
29	.04	.02	.21	.05	.23	.28		.27
30	.06	0	.21	.02	.27	.18		.28
XVIII Nov. 10	.01	0	.21	.06	.19	.24		.31
11	.02	.04	.18	.06	.17	.24		.31
12	.05	.04	.20	.06 (1)	.20	.24		.30
13	.04	.02	.17	.06	.15	.29		.29
XIX 17	.03	.02	.19	.04 (1)	.20	.24		.30
18	.02	.03	.20	.06 (1)	.20	.26		.30
19	.06	.06	.24	.08	.20	.24		.30
20	.05	0	.24	.06	.26	.19		.29
16 March 30	.10	0	.43	.11 (1)	.45	.11	.1	.04
31	.08	.02	.46	.10	.51	.08		.04
April ~~A~~ 2	.01	.08	.46	.12	.47	.07		.03
I 4	.03	0	.42	.12 (1)	.42	.07		.05
5	.01	.07	.39	.06 (1)	.47		.02	.05
6	.02	.02	.40	.11	~~.59~~ .39	.05		.06
7	.07	.08	.39	.10	.40	.04		.06
II 13	.05	.02	.40	.11	.39	.07		.07

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

14	·03		0		·37	·10	·36	·09		·08
15		·07		·02	·39	·12 (1)	·36	·05		·11
IV May 10	·11		·09		·37	·12	·34	·10		·10
13	·02			·07	·34	·09	·35	·12		·10
15		·07		·02	·40	~~·09~~ ·09	·44	·05		·11
16		·03		·09	·41	·14	·36	·12		·11
V June 1	·04			·02	·31	·06	·35	·13		·11
2	·08		0		·30	·09	·29	·12		·06
6	·10		0		·30	·09 (1)	·28	~~·43~~ ·13		·07
VI June 19		·08		·10	·30	·07	·31	·09		·13
20	·01		·01		·29	·07	·30	·11		·13
21	·01			·01	·30	·10 (1)	·28	·11		·12
VII July 14		·05	0		·31	·06	·35	·08		·16
17		·03		·10	·32	·07	~~[illegible]~~ ·35	·11		·07
19		·03	0		·36	·07	·41	·02		·07
VIII 24	·04		0		·33	·06	·38	·10		·09
25		·01		·03	·32	·05	·39	·09		·09
26		·03	0		·34	·06	·40	·06		·10
IX Sept 28	·11		~~·12~~ 0		·25	·03	·31	·09		·01
30	·06		~~·08~~ 0		·22	·015	·30	·06		·02
Oct 2	·05		0		·22	·01	·30	·07		·03
3	·11		0		·21	·08	·26	·12		·05
X Oct ~~11~~		·03		~~·01~~						
12		·06		·05	·24	·03	·41	·08		·11
14		·08	0		·24	(1) ·08	·49	·00		·08
16	·05		·02		·17	·02	·30	·11		·10
18	·04		·02		·25	·005 ~~·00~~ ~~·005~~	·36	·08		·09
19	·06		·08		·25	·01	·39	·06		·09

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(1) Single polar star

XI Nov 14		.07		0	.33	.02 (1)		.46	.03			.11	
15 ~~16~~		.03		.01	.33	.05		.39	.08			.12	
21		.15		.07	.32		.00	.48	.08			.18	
1917													
I March 13	.01			.01	.46	.08		.54	.06			.05	
14	.09		.07		.45	.05		.57	.04			.03	
15	.10			0	.41	.08		.47	.12			.04	
II 24		.02		.07	.48	.08		.56	.04		~~.03~~ .004	.01	
26		.04		0	.39		.04	.64		.03	.00	0	
29	.02		.02		.42	.03 (1)		.57	.01		~~.024~~	.02	
30		0		0	.41	.04		.53	.03		.024	.04	
III April 14	.05			0	.42	.05		.53		.05	.00		.11
16	.07		.03		.41	.06		.50		.04	.007		.09
19	.05			.02	.47	.06		.58		.02	.012		.08
IV April 26	.10		.05		.46	.09		.51	.014		.004		.04
27	.04		.03		.47	.08		.55		.03			.05
30	.07			.01	.46	.14		.44	.03		.006		.04
V May 22	.10		.04		.42	.09 (1)		.47	.11			.07	
23	.11			.05	.43	.09 (1)		.48	.10			.06	
24	.11		.04		.44	.10		.48	.10		.005	.05	
26	.10		.01		.41	.06		.50	.10		.005	.04	
VI June 4	.01			.06	.37	.06		.44	.09		.008	.04	
5		.04		.06	.39	.08		.43	.07		.006	.06	
7	.03			.01	.38	.10		.39	.11		.065	.09	
8		.04	.02		.39	.05		.49	.03		.012	.10	
VII June 25		.02		.06	.34	.12'		.29 ~~.48~~	.12		.009	.10	
26	.10		.03		.32	.11		.27	.14		.008	.10	

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...e 27	0			.01	.34	.10		.33	.10		.006	.11		
II Sept. 19		.05	0		.26	.04		.31	.03		.007	.09		
20		.03		.02	.23	.04		.27	.08		.022	.11		
22	.03			.04	.25	.04		.25	.12			.15		
24		.08		.02	.25	.05		.29	.11		.001	.19		
IX Oct 5	.04			.01	.18	.04		.20	.06		.023	.05		
6	.06		.01		.17	.05		.18	.08		.012	.05		
9	.15 ~~.09~~			.08	.23	.06		.23	.08		.006	.04		
X Dec 7		.02		.07	.39		.01	.57	.16		.013	.14		
10	.06			.01	.34	.04		.43	.16		.005	.12		
14		.02		.09	.35		.03	.51	.16		.009	.11		
I Dec 20	.01		.01		.36		.01	.53	.09		.10	.12		
22	.06		.06		.36	.05		.44	.17		.008	.12		
27	.11			.04	.39	.02		.53	~~.14~~ .12		.006	.13		
1918														
May 18		.04	0		.462	.09		.528	.03		.006	.08		60.6
19		.07	.01		.47	.07		.56		.02	.016	.06		59.5
24		.06	.04		.45	.04		.59	,	.06	.022	.03		63.5
26		.05	.01		.43	.01 (1)x		.61		.16		.02		58.2
I June 4		.04	0		.43	.11		.43		.03	.018	0		59.5
5	.02		0		.42	.12		.41	.01	~~.01~~	.036		.01	61.6
7	.05		.02		.37	.07		.42	.01		.009		.02	58.1 2.2
III July 24	.04		0		.30 ~~.347~~	.09		.28	.04		.009	.02		59.1 1.9
26		.07		.08	.36	.10 (1)		.35		.05			.05	61.
27		.05		.08	.32	.09		.32		.01	.004		.03	60.

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(1)x Single polar ~~spect~~ observation

(1) adopted.

I Aug 13		.01	.05		.31	.03 (1)	.41		.05		.01		61.4
14	.03		.01		.31	.06	.35	.02		.007		.00	60.7 1.3
15		.02		0	.30	.05	.36		.02	.002		.00	59.0 1.0
II Sept 25		.03		.07	.29	.000	.43		.07	.015	.03		49.5 .9
27	.03			.02	.28	.07 (1)	.28		.05		.02		47.3
28		.11		.03	.28	.03	.37		.06	.006	.02		45.9 .2
VI Nov 14		.10		.05	.33	.04	~~.53~~ .42	.02		.030	.09		
16	.05		.12		.34	.06	.39	00		.016	.08		
18		.10		.09	.29	.07	.30	.06	•	.002	.08		
VII Dec 9	~~.07~~	.07	.02		.40	.05	.51		.01	.002	.19		
13	.04			0	.41	.06	.51	.04		.018 ~~.031~~	.14		
19	.03			0	.33	.01	.45	.09		.011	.09		
I Jan 16	.09		.01		.39	.05 (1)	.48	.09			.04		
17		.02		0	.41	.04	.53	.02		.004	.04		
22	0			0	.40	.04	.53	.05		.007	.06		
April 4		.05	.07		.51	.12	.53		.02	.002	.10		
8	.02		.04		.50	.13	.51	.02		.015	.06		
12	0			0	.48	.10	.52	00		.014	.01		
II 20		.06		0	.51	.07	.63		.08		~~.14~~	.07	
26	.07			0	.41	.08	.47	.07	.03	.012	.06	~~.08~~	
May 2	.04			6	.45	.07	.52	.04		.027 ~~.027~~	.03	~~.02~~	
May 19		.06	.03		.44 ~~.47~~	~~.13~~ .07	.52 ~~.47~~	.02	~~.02~~		.11		
20		.08		.02	.47	.13 (1)	.47		.02		.17		
26	.02			0	.44	.09	~~.65~~ .49		.05			.08	

(1) Single polar

I Ju~~ly~~ne 25	.04		.01		.32	.11	.28	.12			.13	
28		.01		0	.33	.09	.32	.11		.005	.14	
30	.04			0	.30	.13	.22	.14			.14	
VI July 25	.03			.02	.38	.11	.37		.02		~~.06~~	.06
28		.01	.06		.38	.05	.47	.	.14			.10
30	.06			.01	.37	.12	.48	.02				.05
VII Aug 5		.03		0	.35	.11	.32	.03			.07	
6	.01		.04		.37	.14	.31	.05			.09	
9		.08		.02	.38	.15	.29	.08			.17	
XIII Aug 14		.12	.06		.36 *	.10	.35		.06		.11	
16		.03	.02		.32	.09	.32	.03			.10	
19		.03		0	.29	.12	.22	.06			.11	
X 27	.10			.04	.27	.16	.11	.20			.11	
29		.10	.04		.34	.11	.31		.05		.10	
Sep 2		0		.06	.28	.09	.25	.13			.10	
X Oct 6		.05	.06		[illegible]	.01	.43	.04			.16	
8		.12		.03	.34	.06	.39	.03			.14	
14	.11		.01		.23	.06	.23	.10		.014	.14	
15	.02			.01	.26	.06	.27	.15		.009	.15	
16	.04			0	.29	.09 (1)	.26	.15			.15	
XI Nov												
14	.03		.05		.32	.10	.29	~~.09~~ .14			.26	
15	.01		.01		.32	.10	.30	~~.07~~ .17		.007	.24	
17	.04		.08		.46	.15	.41	.06			.20	
XII Dec 4	.	.04		.05	.44	.01	.65	.05			.06	
11		.05		0	.46	.007 (1)	.67	.02	.08		.05	
16	.04		.03		.44	.04	.58	.08			.10	

Jan 17	.10	.04	.49	.05	.63	.10	.010	.07
19	.10	.06	46	.005	.67	.13		.08
21	.03	.01	.49	.02	.69	.01		.06
II Feb 2	.07	.07	.53	.03	.74	.04		.09
4	.01	.01	.44	.03	.60	.05		.09
5	.07	.02	.45	.05	.58	.05		.11
6	.02	.08	.47	.05	.60	.04		.11
7	.11	.07	.43	.06 (1)	.53	.13		.11
III Feb 10	.13	.12	.49	.05	.64	.08		.12
11	.14	.11	.49	.07	.59	.07		.13
13	.05	.06	.38	.02	.59	.12		.13
Feb 16	.04	.05	.45	.06	.57	.13		.14
17	.10	.04	.43	.002	.63	.07		.14
21c	.05	.08	.42	.05	.55	.10	.002	.16
24	.08	.07	.47	.01	.70	0 0		.16
Feb 25	.06	.10	.44	.05	.57 ~~.65~~	.11 ~~.02~~		.16
26	.04	.05	.48	.05	.62	.06		.17
27	.03	.10	.47	.06	.59	.07	.007	.17
I March 9	~~0~~ .05	.04	.45	.02	.62	.07		.11
11	.09	.02 ~~.04~~	.45	.02	.70	.01		.12
13	.12 ~~.09~~	.02	.46	.01	.66	.04	.007	.15
18	.06	.03	.47	.01	.68	.06		.16
VII April 30	.09	.03	.43	.06	.53	.11	0 0 0	.07
May 3	.02	0	.42	.01	.60	.08	.006	.09
4	.10	.05	.43	.02	.61	.05	.009	.11
I May 10	.04	.01	.44	.08	.51	.11	.001	.19
13	.06	0	.46	.07	.56	.07	.026	.14
15	.04	.02	.48	.09	.55	.09	.036	.10

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IX May 20		.04	~~0~~	.07	.44	.07		.52	.06		.001	.05	
22		.08	.04	~~.04~~	.47	.06		.58	.04			.09	
23		.03		.03	.45	.08		.53	.10			.12	
X June 14		.08	0		.48	.12		.50	.14		.013	.26	
15	.05		.07		.45	.11		.47	.16		.013	.22	
16		.04	.01		.43	.07		.53	.09 ~~.09~~		.007	.17	
17	.03			.07	.45	.10		.48	.19 ~~.18~~		.028	.13	
19	.08		.05		.37	.02		.51 ~~.57~~	.11			.10	
XI June 23		.07		.01	.39	.02		.54	00		.007	.07	
25	.05			.01	.39	.09		.42	.13		.001	.11	
26	.03		.02		.37	.04		.47	.09 ~~.08~~		.009	.10	
XII July 17	.03			.02	.38	.02		.53		.03	0 0	.07	
20	.05		0		.39	.04		.50	.12		.013	.03	
21	.08		.05		.39	.05		.50	.01		.026	.01	
XIII Sept 15		.05	0		.31	.04		.39	.06		.001	.13	
16		.03		.05	.31	.07		.33	.10			.11	
17	0		0		.33	.08 (1)		.35	.08		.004	.09	
XIV Oct 6		.02		.05	.36	.05		.44	.08			.07	
7		.04		.02	.36	.02		.52	.02		.006	.06	
8	.07		.04		.34	.04		.44	.04		.000	.03	
XV Nov 19	.06			.04	.34		.05	.59	.07		.014	0	
20	0		.03		.31		.09	.62	~~.04~~ → .01		.005	.02	
22	.03			.04	.30		.03	.50	.12 ~~.09~~		.001	.07	
23	.05		.05		.32	.02	~~.0~~	.47	.08		.005	.09	37°
24		.03	.08		.37	.00		.54		.01	.008	.11	41.3
25	0			.10	.37	.10		.37	.20		.004	.15	43.2
II Dec 14	.06			.02	.38	.05		.46	.10		.006	.05	36.6
16		.07		.01	.40	.02		.55	.01		.012	.05	34.9 .12

17	.06.	.02	.39	.03	.54	.02	.001	.06	31.9 .6
XVII Dec 21	.05	.04	.40	.03	.64	.04	.001	.06	44.0
22	.03	.02	.39	.003	.58	.07	.004	.05	39.5
23	0	.02	.38	.01	.54	.08 ~~.05~~	.007	.06	35.7 .105
1921									
Jan 3	.01	.05	.42	.004	.61	.07	.002	.04	46.0
4	.06	.06	.37	. .08	.69	.02	.009	.02	44. 2.4
5	.04	.02	.40	.03	.65	.01	.002	.00	44.4
6	.07	.02	.38	.03	.62	.09	.011	.03	45.7 1.0
7	.07	.02	.38	.01	.59	.08	.009	.05	41.5
Jan 13	.02	0	.37	.05	.64	.06	.007	.09	35.5 .6
14	.05	.04	.38	.03	.61	.07	.014	.09	35.3 .6
18	.02	.04	.38	.05	.64	.08	.00	.04	37.7 .1
19	.12	.03	.43	.05	.73	.05	.006	.04	40.
IV Feb 2	.06	.02	.45	.10	.84	.18	.002	.09	38.8
3	.08	.03	.43	~~.03~~ .02	.66	.02	.008	.07	37.1
4	.01	0	.46	.01	.70	.05	.001	.05	36.2
V Feb 8	.05	.01	.45	.005	.68	.02	.010	.02	36.2
9	0	.03	.47	.02	.72	.02	.004	.01	38.5 0
10	.06	0	.44	.02	.69	.08	.007	.01	
11	.02	.02	.47	.01	.71	00	.004.	0	40.6 .2
I Feb 16	.01	.08	.51	.07 (1)	~~.62~~ .62	.11	.000	.04	48.4
17	.06	.01	.49	.03	.75	~~.03~~ .03	.007	.05	45.9 1.4
18	.03	0	.47	.005	.68	.02	.011	.05	42.0 .2.0
~~4~~									
March 9	.04	0	.46	.005 ~~.6~~	.68	.03	.001	.01	46.0
11 8	.07	.04	.43	.04	.67	.01	.032	.02	

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I March 15	.06	.04	.42	.08	.75	.09	.001	.07	46.4 .4
16	.05	.06	.40	.07	.66	.03	.014	.07	46.5 .2
18	.03	.03	.39	.05	.68	~~.03~~ .08	.004	.07	42.2 .5
19	.02	.03	.40	.04	.68	.06	.005	.07	42.7
22	.09	.03	.43	.01	.63	.03	.016	.07	46.5
III March 31	.05	0 ~~.04~~	.46	.00	.67	.01	.008	.05	48.1
April 1	.02	~~.02~~ .04	.52	.02	.74	.07	.005	.09	53.0
2	.02	.02	.47	.02	.72	.06	.001	.07	
4	.03	.06	.43	.01	.62	.0124 .02	.005	.05	44.6
IX May ~~Jun~~ 17	.04	.02	.41	.02	.58	~~.06~~ .06	.014	.05	52.7
19	.06	.01	.37	.03	.580	.01	.019	.05	51.2
20	0	.01	.41	.02	.58	.05	.002	.05	54.9
X June 2	.01	.07	.38	.07	.44	.09	.026	.06	.59 2
3	.06	.03	.42	.03	.57	~~0~~ .03	.006	.07	61.5 .6
6	.09	.06	.39	.09	.42	.11	.002	.10	58.4
7	.06	.02	.42	.07 (1)	.50	.06	.006	.11	64.0
XI July ~~8~~4	0	.02	.38	.11	.36	.12	.005	.12	61.5 1
6	.02	0	.36	.05	~~.58~~ .44	.02	.002	.06	63.2 .4
8	.04	.03	.39	.07	~~.58~~ .44	.00	.010	.00	68.8 .3
XII July 20	.05	0	.29	.03	.38	.04	.009	.09	63.7 2.2
23	.08	.04	.23	.02	.30	.06	.009	.04	57.2 .4
25	0	.03	.31	.009	.44	.02	000.	.01	61.6 .4
XIII Sep 10	.13	0	.22	.03	.27	.16	.019	.07	55.2 .8
12	.03	0	.25	.02	.32	.12	.005	.17	51.1
14	.04	0	.27	.03	.34	.13	.005	.13	52.8
15	.03	.05	.25	.02	.33	.14	.000	.10	51.3 .6
16	0	.03	.29	.02	.47	.00 .10	.009	.04	48.5
XIV Oct 18	.03	.02	.29	.09	.59	.06	.004	.07	60.4
19	0	0	.27	~~.12~~ .11	.59	.04	.023	.06	54.8

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20		.10	0		.26		.10	.56		.01	.005	.11		49.7 .5
22	.07		.01		.22		.04	.41	.13		.004	.11		41.4 .2
XV Oct 31		.05		.04	.35		(1) .01	.54	9 .08			.12		53.8
No 2		.05	.02		.27		.04	.48	.12		.008	.12		40.5
4	0			.01	.32	~~.001~~	.03	.51	.12		.005	.13		47.0
XVI Nov 7		.02		.10	.26		.04	.47	.17		.011	.13		36.3 .11
8		.12		.07	.29		.04	.56	.06		.005	.13		35.8 .3
9		.04		.02	.31		.02	.50	.08		.005	.13		39.9
10		.02		.03	.33		.004	.49	.13		.000	.14		44.0
XVII Nov 29	.03			.02	.37		.009	.56	.10		.008	.08		46.2 .5
30	.11		.06		.34		.04	.57	.09		.006	.06		42.5
Dec 3	.03			.05	.35		.02	.53	.07		.023	.01		43.9 $\boxed{9.2}$
XVIII Dec 5	.01		.01		.43		.002	.64		.02	.016		.02	47.9
6	.04			.01	.42		.04	.69	.01		.011		.03	51.0 .05
8	.02			.02	.44		.02	.69	~~.10~~ .10	.00 ~~.10~~	.016		.03	52.0 .2
9	.09		.01		.41		.02	.63	.04		.001		.02	
IX Dec 12		.02		.06	.40		.04	.66	.03		.002		0	46.1
13	.03		.02		.37		.04	.60	.00		.011		0	43.1 .4
14		.04		.05	.40		.04	.67		.02	.001	.01		45.6 .5
15	0		.01		.37		.07	.66	.01		.007	.02		42.6 .6
16	.01			.01	.43	.01	.	.62	.05		.005	.03		47.5
17	.01		.10		.40		.03	.64	.04		.006	.14		45.2 .5
XX Dec 19		.08		.12	.41	.03		.56 ~~.69~~	.14		.002	.13		47.5
20	.04		.05		.34		.06	.66	.00		.024		0	38.7 .4
21	.02		.03		.42		.002	.63	.06			.03		46.0
22	.06			0	.37		.08	.69	.01		.012		.05	43.1 .8
23	.04			.05	.34		.08	.64	.05		.007		.02	39.0 1.5

1922

March 1	.04	.05	.45	.03	.62	.03	.008	.03	44.0 .4
2	.08	.02	.44	.01	.64	.01	.004	.06	42.8 .2
3	.01	.07	.47	.01	.68	.02	.012	.06	46.6 .2
4	.06	.0	.43	.004	.64	.03	.007	.02	42.7 .3
March 6	.06	.04	.44	.005	.64	.01	.019	.02	44.0
7	.01	.04	.41	.01	.61	.01	.012	.04	42.3 .3
8	.09	.03	.43	.03	~~.56~~ .61	.01	.005	.06	41.9 .6
9	.01	.05	.40	.01 (1)	~~.73~~ .61	00	00	.07	39.2
10	.03	0	.43	.04	.57	.03	.00	.08	40.2 .2
II March 13	.05	0	.47	.01	.67	.034	.006	.00	43.6
14	.04	.01	.45	.04	.63	.00	.012	.03	42.0 .9
20	0	.01	.44	.03	.600	.01 .00	.012	.02	37.8
IV April 3	.10	.04	.46	.02	.65	.07	.004	.01	38.9
4	.01	.08	.44	.06 (1)	.55	.05		.01	37.8
6	.05	.02	.44	.035	.59	.01	.002	.01	40.7
7	.00	.05	.46	.02	.64	.06	.004	.01	41.6
V April 18	00	0	.45	.08	.51	.034	.006	.05	43.2
19	.07	0	.48	.07	.60	.07	.002	.06	45.8
20	.10	.03	.46	.07	.56	.00	.008	.07	46.0
VI May 1	.04	.03	.47	.09	.54	.01	.001	.03	45.1
2	0	.02	.46	.09	.52	.04	.001	.03	46.1 .5
3	.04	.02	.46	.07	.56	.00	.010	.03	47.1
4	.04	0	.43	.07 (1)	.51	.05		.03	46.1
VII June 5	.08	0	.35	.13	.29	.13	.036	~~.09~~ .09	52.9 1.4
6	.0	.03	.40	.13 (1)	.37	.06	.004	.10	55.9 .2
7	.06	.05	.47	.16	.40	.07	.006	.11	63.1
8	.05	.09	.47	.16 (1)	.40	.13	.011	.13	66.8
VIII June 19	.06	0	.39	.17	.28	.16	.001	.13	57.0

20	.01		.08		.37	.08	.40	.05		.022	.14	56.3 1.3
23	.05		0		.35	.15	.25	.15		.007	.14	54.3
IX July 3		.01		.07	.36	.16	.26	.15		.009	.13	55.1
4	.09		0		.33	.14	.25	.17		.022	.13	
6	0			.03	.35	.14	.26	.14		.012	.14	52.2
7		.09	.02		.36	.08	.38	.03		.004	.15	55.0
X July 31		.05		.02	.33	.09	.34	.06		.023	.10	54.9 .6
Aug 1	.01		.02		.33	.07	.36	.06		.001	.09	55.8 .9
2	.04		.05		.31	.06	.35		.06	.007	.06	54.7 .5
3	.02			.01	.35	.08	.37	.03 ~~.05~~		.020	.04	56.7 .7
XI July 17	o		o									
18		.11	.03		.36.	.04	.46.		.06	.002	.08	56.9
19		.01		0	.36	.09	.37	.08		.009	.07	58.1 .2.
XII Sept 7	0			.01	.35	.05	.43	.02		.021 ~~.027~~	.03	57.2
8	.07			.01	.31	.10	.27	.15		.002	.10	54.0
9		.05	.02		.33	.08	~~.48~~ .35	.04 ~~.07~~		.012	.02	55.2
XIII Oct 24	0			.05	.35	.04 ~~.15~~	.45	.10		.004	.07	
25	.07		.03		.33	.07	.36	.09		.001	.07	
27	.09		.02		.33	.09	.34	.11		.008	.07	40.8
XIV Nov 7	.02			.03	.39	.10 ~~.08~~	.41	.11		.006	.09	44.7 .6
8	.03		.03		.39	.08	.44	.08		.002	.09	44.0
9	0		.03		.37	.06	.44	.05		.002	.09	41.0 .2
XV Nov 13	.05		.02		.40	.05	.51	.05		.002	.04	49.9
15		.08		.08	.39	.03	.51	.05		.010	.06	46.7
17		.02		.09	.41	.10	.42	.12		.005	.09	49.0
XVI Dec 14		.04		.04	.40	.01	.58	.05		.007	.07	46.3 .3

15	.02			.07	.41	.11	.41	.14		.009	.08	44.0
18		.05		.03	.44	.11	.46	.03		.002	.07	39.1
19		.02		.01	.45	.10	.49	.04		.019 ~~.038~~	.07	41.4
1923												
I Jan 8	0		0		.45	.05	.58	.05		.004	.07	44.8
9	.04		.02		.42	.07	.51	.09		.028	.07	39.8
10	.04			.05	.42	.09	.45	.13		.006	.06	.2 39.9
11	0			0	.43	.06	.54	.06		.010	.07	38.9
12		.01		0	.42	.04	.54	.05		.011	.08	.2 37.4
I Jan 19		.02	.03		.50	.06	.64		.02	.005	.04	46.0
22		.03		.03	.50	.07	.61	.04		.005	.05	45.2
24	.02			0	.52	.09	.60	.05		.002	.04	46.3
26		.03		0	.51	.06	.66		.02	.004	.01	46.5
I Jan 31	.07			.02	.52	.12	.55	.08		.002	.02	49.5
Feb 2		.02	.03		.49	.03	.67		.03	.024	.01	.4 47.6
3	.10		.03		.46	.07 ~~.46~~	~~.07~~ .55	.07		.006	.01	45.0
5		.09	.01		.46	.00	.68		.07	.004	.02	44.8
I Feb 7		.01		.05	.48	.11	.52	.07		.013	.04	40.2
8	.10			.01	.42	.06	.52	.09		.020	00	40.5
9	.04			0	.46	.07	.55	.07		.012	.04	41.8
I April 25	.02		.07		.48	.08	.57	.03		.006	.09	45.1
27		.11		.02	.47	.05	.60	.01		.019	.10	43.8
28		.05	0		.45	.05	.57	.03		.009	.09	43.2
30		.04		.02	.52	.10	.58	.06		.005	.09	49.2
I May 10	0		0		.39	.11	.37	.21			.25	41.9
12	0		.10		.41	.11	.41	.12		.007	.24	43.3
17		.03		.01	.41	.11	.34	.153		.005	.20	44.0
24	.08			0	.41	.15	.34	.19		.011	.14	47.3

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VII August 26		.05	0		.28		.04	.47	.11	.015	.18	54.8
28	.03		0		.27		.01	.43	.16	.004	.16	55.3
30	.02		0		.25		.03	.41	.14	.007	.15	51.4 .5
31		.01		.04	.26		.02	.42	.13	.006	.14	51.5
VIII Sept 12	.11		.02		.27	.00		.39	.18	.002	.12	54.0 .57
14	.08			.04	.27	.03		.35	.23	.016	.15	55.3 .9.0
16	.01			.01	.28	.04		.34	.17	.005	.18	51.9 1.0
IX Sept 18		.06		.01	.29	.02		.40	.14	.004	.22	50.9 .7
21	.03		0		.26	.05 (1)		.29	.21	.001	.22	48.4
22		.02	0		.29	.03		.38	.16	.006	.21	49.9 .2
X Oct 3	.05		.01		.25	.01		.35	.17 ~~.14~~	.014	.16	46.9
4	.03		0		.27	.04		.33	.16	.026	.16	44.7 .4
5	.05		0		.31	.05		.36	.15	.004	.13	47.9
XI Oct 30		.16		.07	.36	.03		.49	.14	.042	.25	52.5
31	.02		.02		.31	.04		.37	.22	.008	.26	49.4
Nov 1	.01			.02	.30	.06		.34	.24	.012	.26	47.6
XII Nov 3	.06		.04		.28	.04		.36	.23	.000	.26	45.0
6	.05			.01	.26	.07		.26	.28	.007	.28	38.0
7	.07		0		.25	.08		.24	.28	.000	.27	37.0
XIII Nov 14		.03		.06	.32	.01		.44	.19	.001	.20	38.5
16	.08		0		.30	.05		.35	.25	.001	.22	37.1
17	.02		0		.31	.02		.42	.22	.004	.23	36.1
XIV 22	.0	.07	0		.35	.01		.50	.16	.00	.26	36.7
23		.12		.04	.34	.01		.49	.17	.040	.28	34.7
24		.07	0		.34	.01		.50	.17	.001	.27	33.1
XV Dec 3	.08			.02	.35	.03		.48	.19	.001	.13	36.1
5		.02	.04		.39 ~~.43~~	.02		.55	.08		.16	37.8
6		.07	.06		.39		.02	.61	.64		.13	

XII. Dec 13	.05	0	.38	.03	.51	.26	.00	.26	43.0
14	.08	0	.43	.04	.57	.16	.004	.27	44.9
17	.05	.05	.45	.11	.48	.24	.008	.29	47.7
18	0	.03	.41	.03	.55	.22		.30	41.0
19	.07	.02	.38	.00	.55	.22	.005	.31	35.7

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TABLE I

Column
1. - Date
2. - Riefler error as obtained from T.C. Observations by the ordinary method of reduction i.e. using the level error 1.
3. - Plotted error of Riefler from [2].
4. - Erratic = T. C. - Plotted error = 2-3.
5. - [A -a] cosec φ
6. - Riefler error as obtained from T.C. observations with A and a.
7. - Plotted error from 6.
8. - Erratic = 6 - 7.
9. - Plotted error with 1 - Plotted error with A = 3 - 7.

14		.68						
15	.66	.71	5	.01	.67	.66	1	.05
16		.74						
17	.47	.77	0	.00	.77	.73	4	.04
18		.80						
19	.81	.83	2	.01	.82	.79	3	.04
20		.86	3					
21	[illegible]	.89						
22	.90	.93	3	.05	.85	.88	3	.05
23		.96						
24	0.01	.99	2	.06	59.95	59.95	0	.04
25		.02						
26	.02	.05	3	.02	.04	.04	0	.01
27		.10						
28		.15						
29		.19						
30		.24						
31	.36	.29	7	.10	.25	.27	2	.02
Feb 1		.34						
2	.37	.39	2 ~~.04~~	.04	.41	.38	3	.01
3	.53	.43	10	.08	.45	.42	3	.01
4	[illegible]	.48						
5	.44	.53	9	.08	.52	.51	1	.02
6		.58			~~.59~~			
7	.62	.63	1	.08	~~.49~~ .54	.59	5	.04
8	.77	.67	10	.16	~~.56~~ .66	0.67	1	.00
9	.76	.72	4	.08	.68	.68	0	.04
10		.77						

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	ℓ				A			
	T.C	Plotted error	Errati	A-a corr	T.C	Plotted error	Errati	$P_L - P_A$
11		.82						
12		.87						
13		.91						
14		.96						
15		1.00						
16	0.95	.00	5	.07	.88	88	0	.12
17		.00						
18		.00						
19		1.00						
20	1.04	0.99	5	.09	.95	0.96	1	.03
21		.98						
22		.97						
23	.93	.96	3	.06	.87	.90	3	.06
24		.94						
25		.93						
26	.90	.92	2	.07	.83	.87	4	.05
27		.91						
28		.90						
March 1		.89						
2		.87						
3	.83	.86	3	.04	.79	.77	2	.09
4		.85						
5	.86	.84	2	.13	.73	0.74	1	.10
6	.85	.83	2	.07	.78	.76	2	.07
7		.83						
8		.83						
9		.83						
10		.82						
11		.82						
12		.82						
13		.82						
14		.82						
15		.90						
16	.87	.89	2	.02	.85	.84	1	.05
17	.84	.88	4	.00	.84	0.85	1	.03
18		.88						
19		.864						
20		.86						
21		.86						
22		.85						
23		.84						
24		.84						

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	T.C error	Plotted error	Erratic	(A−a) corr^{n}	T.C error	Plotted error	Erratic	
6		.61						
7		.61						
8		.62						
9		.63						
10	.63	.63	0	.25	.38	.38	0	.25
11		.62						
12	.62	.62	0	.14	.48	.38	10	.24
13		.61						
14		.60						
15		.60						
16		.59						
17	.55	.58	3	.18	.37	.38	1	.20
18		.58						
19		.57						
20		.56						
21		.55						
22		.54						
23		.53						
24	.61	.53	8	.22	.39	.39	0	14
25		.52						
26		.51						
27		.50						
28		.50						
29		.50						
30		.49						
31		.48						
	June 1st to August 1st T.C out of use.							
August 1	58.65	58.67	2	.04	58.61	.61	0	.06
2		.72						
3	58.75	.77	2	.09	.66	.69	3	.08
4		.82						
5		.87						
6		.92						
7		.97						
8		59.03						
9	59.08	.08	0	.13	.95	.95	0	.13
10		.13						
11	59.18	.18	0	.19	58.99	.01	2	.17
12		.23						
13	59.28	.29	1	.14	59.14	.09	5	.20
14	59.37	.34	3 ~~16~~	.26	59.11	.12	1	.22
15	59.39	.39	~~3~~ 0	.22	59.17	.16	1	.13

	l				A			
	T.C error	Plotted error	Erratic	A - a Corr. cp	T.C error	Plotted error	Erratic	$P_L - P_A$
25		.83						
26		.82						
27		.81						
28		.80						
29		.78						
30		.77						
31		.75						
April 1		.74						
2		.73						
3	.68	.71	3	.06	.64	.61	3	.10
4		.70						
5	.65	.68	3	.06	.59	.59	0	.09
6		.67						
7		.65						
8		.63						
9		.61						
10		.60						
11		.58						
12		.56						
13		.55						
14	.51	.53	2	.08	.43	.43	0	.10
15		.51						
16		.50						
17	.46	.48	2	.07	.39	0.39	0	.09
18		.49						
19		.49						
20		.50						
21		.51						
22		.51						
23	.51	.52	1	.10	.41	.43	2	.09
24		.53						
× 25	.55	.53	2	~~.04~~ .18 .04	~~.51~~ .40 .51	.44	7	.09
26		.54						
× 27	.44	.55	11	.01	.43	.45	2	.10
× 28	.50	.55	5	.04	.46	.46	0	.09
29		.56						
30	.53	.57	4	.07	.46	.48	2	.09
May 1		.57						
2		.58						
3	.56	.59	3	.05	.51	.51	0	.08
4	.57	.59	2	.13	.44	.48	4	.11
5		.60						

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	T.C error	Plotted error	Erratic	A-a error cp	T.C error	Plotted error	Erratic	
16		59.44						
17		.49						
18		.54						
19		·56						
20		.59						
21	59.60	.61	1	~~.13~~ .15	.45	.466	1	.15
22	59.61	.63	2	~~.13~~ .13	.48	59.48	0	.15
23		.65						
24		.68						
25	59.65	.70	5	.13	.52	.52	0	.18
26		.72						
27		.74						
28	59.80	.77	3	.19	.61	.61	0	.16
29		.79						
30	59.84	.82	2	.17	.67	.67	0	.15
31	59.83	.84	1	.17	.66	.70	4	.14
Sept 1		.86						
2		.88						
3		.91						
4	0.05	.93	12	.19	59.86	.83	3	.10
5		.96						
6		.98						
7	0.08	0.01	7	.15	59.93	.92	1	.09
8		.03						
9		.06						
10		.08				000		
11		.10						
12	.24	.13	11	.21	0.03	.01	2	.12
13		.15						
14	.25	~~.20~~ .17	8	.27	59.98	.02	4	.15
15	.21	.20	1	.20	0.01	.02	1	.18
16		.22						
17		.24						
18	.19	.25	6	.17	0.02	.03	1	.22
19		.25						
20		.26						
21	.29	.26	3	.25	.04	.04	0	.22
22	.24	.26	2	.19	.05	.05	0	.21
23		.27						
24		.27						
25		.28						
26		.28						

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	l				A			
	T.E error	Plotted error	Erratic	A - a err l	T.E err	Plotted err	Erratic	$P_L - P_A$
27		.28						
28		.29						
29		.29						
30		.30						
Oct 1	.36	.30	6	.23	.13	.13	0	.17
2		.31						
3	.36	.31	5	.20	.16	.15	1	.16
4	.35	.32	3	.19	.16	0.16	0	.16
5	.37	.32	5	.18	.19	.19	0	.13
6		.33						
7		.38						
8		.43						
9	.49	.48	1	.22	.27	.29	2	.19
10		.53						
11	.55	.58	3	.20	.35	0.34	1	.24
12		.62						
13		.67						
14		.72						
15		.77						
16		.82						
17		.87						
18		.92						
19	.94	.97	3	.12	.82	0.82	0	.15
20	1.01	1.02	1	.19	.82	.85	3	.17
21		.07						
22		.12						
23		.17						
24	1.21	1.22	1	.23	.98	.98	0	24
25		.26						
26	1.23	.23	0	.23	1.00	1.00	0	.23
27		.21						
28		.18						
29		.15						
30	.97	.13	16	.17	.80	.87	7	25
31	1.12	.10	2	.26	.86	.84	2	.26
Nov 1	1.08	.07	1	.29	.79	.81	2	26
2		.05						
3	1.08	1.02	6	.28	.80	.76	4	.26
4		0.99						
5		.96						
6	.98	.93	5	.34	.64	.65	1	.28
7	.98	.91	7	.34	.64	0.64	0	.27

			l				Δ			
	T.C error	Plotted error	Erratic		(A-a) corr	T.C error	Plotted error	Erratic		$P.E_l - P.E_Δ$
8	.88	.88	0		.30	.58	59.63		5	.25
9	.86	.86	0		.26	.60	.62		2	.24
10	.83	.83	0		.17	.65	.61	4		.22
11		80								
12		.77								
13		.77								
14	.74	.77		3	.23	.51	.57		6	.20
15		.77								
16	.85	.77	8		.30	.55	0.55	0		.22
17	.79	.77	2		.25	.54	.54	0		.23
18		.77								
19		.78								
20		.77								
21		.78								
22	.70	.77		7	.19	.51	.51	0		.26
23	.66	.78		12	.20	.46	.50		4	.28
24	.70	.77		7	.20	.50	.50	0		.27
25		.78								
26		.78								
27	.77	.78		1	.20	.47	.56		9	.22
28		.78								
29	.81	.78	3		.25	.56	.58		2	.20
30		59.73								
Dec 1		.73								
2		.73								
3	59.81	.73	8		.23	.58	.60		2	.13
4		.74								
5	.72	.74	4	2	.10	.62	.58	4		.16
6	59.67	.74		7	.05	.62	.56	6		.18
7		.74								
8	59.76	.75	1		.23	.53	.53	0		.22
9		.75								
10		.78								
11		.~~7~~81								
12		.84								
13	59.92	.87	5		.31	.61	.61	0		.26
14	.82	.90		8	.19	.63	.63	0		.27
15		.93								
16		96								
17	.04	0.99	5		.29	59.75	.70	5		.29
18	.02	0.02	0		.27	.75	.72	3		.30
19	59.98	.05		7	.26	.72	59.74		2	.31

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

	T.C.	l Plotted error	l Erratic	$(A-a)$ cosec φ	T.C. Error	A Plotted Error	A Erratic	$P_L - P_m$
29		0.00						
30		59.84						
31	59.72	.79	4	.00	59.72			
Feb 1	59.59	.74	15	.05	59.64			
2		.70						
3		.65						
4	59.70	59.60	10	.02	59.72			
5		.65						
6		.71						
7		.76						
8		.81						
9	59.94	.87	7	.02	59.96			
10	59.85	.92	7	.04	59.84			
11	0.00	59.97	3	.07	0.07			
12								
13	R Dismounted & Cleaned							
14								
15	59.97	59.97	0	.04	59.93			
16	0.16	0.05	11	.03	0.13			
17		.14						
18	0.24	0.23	1	.01	~~.23~~			
19		.15						
20	0.09	0.06	3	.00	0.09			
21	0.05	59.99	6	.11	59.94			
22	59.93	.91	2	.08	~~59.85~~ 0.01			
23	59.79	.82	3	.04	59.75			
24	59.64	.74	10	.01	.65			
25		59.65						
26		.76						
27	59.84	.88	4	.02	59.82			
28	.96	59.99	3	.01	59.97	59.97	0	
~~29~~								
March 1	0.06	0.10	4	.04	0.02	0.07		5 .03
2	0.14	.22	8	.00	0.14	0.16		2 .06
3	0.32	.33	1	.02	.34	.27	7	.06
4	0.50	0.44	6	.04	.46	.46	0	.1 .02
5		.47						
6	0.44	.50	6	.00	.44	.48		4 .02
7	0.54	.53	1	.01	.53	.49	4	.04
8	.47	.56	9	.00	.47	.50		3 .06
9	.58	.59	1	.01	.57	.52	5	.07
10	.59	.62	3	.05	.54	.54	0	.08

(877) Wt 6095-54 10m 2/16 M & G Ltd G 14

	e				A			
	T.C	Plotted Error	Erratics	(A-a) error	T.C	Plotted error	Erratics	$P_L - P_A$
11	.65	.65	0	.00	.65	.60	5	.05
12		.68						
13	.64	.72	5	.05	.72	.72	0	.00
14	.79	.75	4	.00	.79	0.78	1	.03
15		.78						
16		.81						
17		.84						
18		.86						
19		.87						
20	.89	.89	0	.01	.88	.87	1	.02
21		.90						
22	.89	.91	2	.02	.87	.90	3	.01
23		.92						
24	.93	.93	0	.00	.93	.93	0	.00
25		.94						
26		.95						
27		.96						
28	.97	.97	0	.02	0.99	.99	0	.02
29		.97						
30		.97						
31		.98						
April 1		.98						
2		.98						
3	.88	.98	.10	.07	.95	.99	4	.01
4	.98	.99	.01	.06.	.92	1.00	8	~~.07~~ .01
5		.99						
6	1.04	.99	.05	.02	1.02	1.00	2	~~.04~~ .01
7	1.00	1.00	00	.06	1.06	1.01	5	~~.01~~ .01
8		.95				1.01		
9		.91						
10		.86						
11	0.80	.82	.02	.01	.81	.83	2	.01
12		.77						
13	0.68	.73	.05	.01	.69	.73	4	.00
14		.68						
15		.64						
16		.59						
17		.55						
18	0.50	.50	00	.05 ~~.05~~	.45	.45	0	.05
19	.39	.46	.07	.01	.40	.40	0	.06
20	.31	.41	.10	.00	.31	0.34	3	.07
21		.37						

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

	l				A			
	T.C	Plotted error	Erratic	(A-a) corr cp	T.C	Plotted error	Erratic	$P_l - P_A$
22		.32						
23		.28						
24	.24	0.24	00	.02	.22	0.22	0	.02
25		.29						
26		.34						
27	.46	.39	.07	.06	.40	.37	3	.02
28	.47	.44	.03	.05	.42	.42	0	.02
29		.50						
30		.55						
May 1	0.56	.60	4	.02	.54	.57	3	.03
2	.65	.65	0	.05	.60	.62	2	.03
3	.66	.70	4	.01	.65	.67	2	.03
4	.79	.75	4	.07	.72	.72	0	.03
5	.80	0.80	0	.02	.78	0.77	1	.03
6		.77						
7	~~.072~~	.75						
8	0.72	.72	0	.01	.71	.71	0	.01
9		.74						
10		.76						
11		.78						
12		.80						
13		.81						
14		.83						
15		.85						
16		.87						
17		.90						
18	0.91	.92	1	.05	.86	.87	1	.05
19	0.92	.94	2	.07	.85	.88	3	.06
20		.96						
21		.99						
22	.96	1.01	5	.04	.92	0.92	0	.09
23		1.03						
24		.06						
25		.08						
26	1.10	1.10	0	.09	1.01	1.01	0	.09
27	0.99	1.02	3	.02	.97	95	2	.07
28		0.94						
29	.90	.86	4	.108	.80	.78	2	.08
30		.78						
31	.70	.70	0	.12	.58	.60	2	.10
June 1		.62						
2	.57	.54	3	.11	.46	.46	0	.09

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

	e					A				
	T.C	Plotted error	Erratis		(A-a) creep	T.C	Plotted error	Erratis		$P_e - P_A$
3	.46	.46	0		.02	.44	.38	.06		.02
4		.38								
5	.38	.30	8		.17	~~.15~~ .21	.21	0		.09
6	.22	.22	0		.07	.15	.12	3		.10
7	.08	.14		6	.10	59.98	.03		5	.11
8	.02	.07		5	.17	59.85	.94		9	.13
9		.00								
10	59.92	59.92	0		.08	59.84	.82	2		.10
11		.85								
12		.78								
13		.70								
14		.63								
15		.56								
16	59.48	.49		1	.19	59.29	.29	0		.20
17		.42								
18		.45								
19	59.53	.47	6		.19	59.34	.34	0		.13
20	.51	.50	1		.07	59.44	.36	8		.14
21		.52								
22		.54								
23	.61	.56	5		19	59.42	.42	0		.14
24		.58								
25		.60								
26		.62								
27		.64								
28	.69	.65	4		16	59.53	.51	2		.14
29	.62	.67		5	12	.50	.53		3	.14
30		.69								
July 1		.71								
2		.73								
3	.73	.74		1	19	.54	.61		7	.13
4	.85	.76	9	1	22	.63	.63	0		.13
5	.	.78								
6	.80	59.80	0		.17	.63	.66		3	.14
7	.74	.83		9	.04	.70	68	2		.15
8		.86								
9		.89								
10		.92								
11	59.93	.95		2	.09	.84	.86		2	.09
12		.98								
13		.01								
14	0.04	0.04	0		.01	.05	.01	4		.03

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

	a				A			
	T.C	Plotted error	Erratic	(A-a) Corr.	T.C error	Plotted error	Erratic	$P_a - P_A$
15		.09						
16		.14						
17		.19						
18	.26	.24	1	.05	.20	.20	0	.04
19		.29						
20		.34						
21	.43	.39	4	.07	.36	.37	1	.02
22	.51	.44	7	.12	.39	.42	3	.02
23		.49						
24		.54						
25	.59	.59	0	.02	.61	0 .58	3	.01
26	.53	.54	1	.02	.55	.53	2	.01
27	.46	.50	4	.05	.41	.48	7	.02
28		.45						
29		.41						
30		.36						
31	.26	.31	.05	.07	.19	.21	2	.10
August 1	.28	.27	1	.08	.20	.18	2	.09
2	.26	.22	4	.05	.21	.16	5	.06
3	.20	.18	2	.07	.13	.14	1	.04
4		.13						
5		.09						
6		.04						
7	.04	0.00	4	.05	59.99	.00	* 1	.00
8		59.97						
9		.95						
10		.92						
11	59.87	.89	2	.10	59.77	.85	8	.04
12	.88	.87	1	.07	.81	59.81	0	.06
13		.84						
14		.82						
15		.79						
16		.77						
17	59.74	.74	0	.07	59.67	.67	0	.07
18	.61	.72	11	.06	.67	.64	3	.08
19	.68	.69	1	.10	.58	.58	0	.11
20		.67						
21		.64						
22		.61						
23	59.53	.58	5	.06	.47	.47	0	.09
24		.55						
25	.51	.51	0	.01	.50	.47	3	.04

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

	l				A			
	T.C error	Plotted error	Errata	(A-a) corr	T.C error	Plotted error	Errata	Pe - PA
18		.49						
19		.55						
20		.61						
21		.67						
22		.74						
23	.79	.80	1	.12	.67	.63	4	.17
24	.82	.86	4	.18	.64	.69	5	.17
25	.92	0.92	0	.17	.75	.75	0	.17
26		.90						
27		.88						
28		.86						
29	.82	.85	3	.08	.76	.80 .76	2	.09
30	.80	.83	3	.07	.73	.73	0	.10
Dec 1	.79	.81	2	.10	.69	.71	2	.10
2	.76	.79	4	.08	.67	.69	2	.10
3		.77						
4		.75						
5	.68	.73	5	.05	.63	.64	1	.09
6	.67	.71	4	.10	.57	.62	5	.09
7		.70						
8		.68						
9	.68	.66	2 3	.08	.60	.57	3	.09
10		.64						
11		.62						
12		.60						
13		.58						
14	.52	.56	4	.07	.45	.49	4	.07
15	.57	.55	2	.19	.40	.47	7	.08
16		.53						
17		.51						
18	.44	.49	5	.05	.39	.42	3	.07
19	.45	.47	2	.06	.39	.40	1	.07
20		.45						
21		.43						
22		.41						
23	.39	.39	0	.06	.33	.33	0	.06
24	~~0.34~~	.33						
25		.28						
26	.23	.22	1	.05	.18	.18	0	.04
27	.17	.17	0	.02	.15	.13	2	.04
28		.11						
29	59.98	.06	8	.05	59.93	.01	8	.05

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

	e				A			
	T.C error	Plotted error	Erratic	(A-a) error	T.C error	Plotted error	Erratic	Pe - PA
7	.79	.78	1	.12	.67	0.67	00	.11
8		.68						
9		.59						
10	.49	.49	0	.07	.42	.45	3	.04
11		.47						
12		.46						
13	.40	.44	4	.14	.26	0.26	0	.18
14	.42	.42	0	.13	.29	.26	3	.16
15		.41						
16		.39						
17	.38	.37	1	.11	.27	.23	4	.14
18	.32	.36	4	.02	.30	.22	8	.14
19	.32	.34						
20	.27	.32	5	.00	.27	.20	7	.12
21	.33	.31	2	.05	.28	.19	9	.12
22		.29						
23		.27						
24	0.25	.25	0	.12	.13	.18	5	.07
25	.31	.24	7	.11	.20	.17	3	.07
26		.24						
27	.32	.23	9	.14	.18	.16	2	.07
28		.22						
29		.22						
30		.21						
31		.20						
Aug 1	.28	.20	8	.23	.05	.11	6	.09
2		.19						
3		.18						
4	.15	.18	3	.07	.08	.09	1	.09
5		.17						
6		.16						
7	.18	.16	2	.14	.04	.07	3	.09
8	.18	.15	3 8	.09	.09	.06	3	.09
9	.14	.14	0	.06	.08	.05	3	.09
10		.14						
11	.10	.13	3	.09	.01	.03	2	.10
12		.12						
13	.23	.18	5	.07	.16	.14	2	.04
14		.24						
15	.22	.30	8	.06	.16	.24	8	.06
16		.36						
17	.41	.43	4 2	.16	.25	.34	9	.09

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

	e				A				
	T.C	Plotted Error	Erratic	(A-a) Corr cp	T.C	Plotted	Erratic	Pe - PA	
26	59.54	.50	.04	.08	.46 59.~~57~~	.47	1	.03	
27		.49							
28		.49							
29		.48							
30		.47							
31	.51	.46	.05	.02	.49 ~~.52~~	.47	2		.01
Sept 1 ~~32~~		.46							
2		.45							
3		.44							
4	59.43	59.43	0	.01	.44	.47	3		.04
5									
6	R stopped								
7	59.50	59.50	0	.04	.46	.47	1	03	.0
8	.64	.57	.07	.18	.46	.47	1	.10	
9	.58	.63	105	.05	.53	59.51	2	.12	
10		59.69							
11		.76							
12		.83							
13		.90							
14		.97							
15	59.94	0.03	9	.13	59.81	59.81	0	.22	
16		.10							
17		.16							
18		.23							
19		0.30							
20		.38							
21	0.44	.47	3	.07	.37	.39	2	.08	
22	.50	.56	6	.05	.45 ~~.46~~	.48	3	.08	
23	.61	.64	3	.01	.60	.59	1	.07	
24		.73							
25		.82							
26		.90							
27		.98							
28		1.07							
29	1.20	.16	4	.12	1.08	106	2	.10	
30		1.25							
Oct 1		1.34							
2	1.30	.25	5	.06	1.24	1.25	1	00	
3		.15							
4		1.06							
5		59.96							
6	.86	.87	1	.06	.80	.80	0	.07	

	l				A			
	T.C	Plotted Error	Erratics	(A-a) Correcⁿ	T.C	Plotted error	Erratics	$P_L - P_A$
20		.08	[illegible]	[illegible]				
21		.11						
⁜ 22	59.31	59.40		.23	59.08			
23		.44						
24		.47						
25		.51						
26		.55						
27		.59						
28	59.64	.64	0	.29	59.35			
29		.68	[illegible]	[illegible]				
30		.72						
31		.77						
22 —								
Jan 1		0.55						
2		.63						
3	0.59	.70		.07	.52			
4	0.70	.78		.08	.62			
5		.85						
6		.93						
7	0.98	1.00		.05	.93			
8		1.03						
9	1.07	1.05		.02	1.05			
10	1.12	1.09		.05	1.07			
11	1.17	1.12		.05	1.12			
12	1.29	1.22		.00	1.29			
13		1.33						
14	1.38	1.37	1	.05	1.33			
15		1.40						
16		1.44						
17	1.34	1.47	.13	.00	1.34			
18	1.47	1.50	3	.08	1.39			
19	1.55	1.54	1	.08	1.47			
20	1.44	1.39	5	.07	1.37			
21	1.24	1.23	1	[illegible] .02	1.26			
22		1.08						
23		.92						
24		.77						
25		.62						
26		.46						
27		.31						
28	59.85	.15	30	.02	59.87			

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

⁜ R Winding interrupted

	l				A			
	T.C error	Plotted error	Erratis	(A−a) corr	T.C error	Plotted Error	Erratis	$P_e - P_A$
30		.00						
31		59.94						
21								
Jan 1		0.03		~~.10~~				
2		.06						
3	.10	.09	1	.10	.00	.05	5	.04
4	.18	.12	6	.02	.16	.10	6	.02
5	.19	.15	4	.02	.17	0.16	2	00
6	.26	.19	7	.12	.14	.16	2	.03
7	.29	.22	7	.10	.19	.17	2	.05
8		.25				.18		
9		.29						
10	.32	0.32	0	.13	.19	.19	0	.13
11		.31						
12		.31						
13	.28	.30	2	.07	.21	.21	0	.09
14	.25	.30	5	.08	.17	.21	4	.09
15	.28	.29	4			.		
16		.28						
17		.28						
18	.29	.27	2 4	.10	.19	.23	4	.04
19	.15	.27	12	.05	.20	.23	3	.04
20		.26						
21		.25						
22	.26	.25	1	.12	.14	18	4	.07
23		.24						
24	~~.20~~	.23	2	.08				
25		.23						
26	.22	0.22	0	.08	.14	.13	1	.09
27		.16						
28		.09						
29	0.10	.03	7	.01	.09	0.10	1	.07
30		59.96						
31		59.90						
Feb 1		.89						
2	59.83	.89	6	.17	.00	.98	2	.09
3	.96	.88	.08	.04	59.92	.95	3	.07
4	.86	.87	1	.06	.92	0.92	0	.05
5		.86						
6		.86						
7		.85						

	l						A					
	T.C	Plotted Error	Erratic		(A−a) error		T.C	Plotted error	Erratic		$P_l - P_A$	
8	59.89	.84	5		.02		59.87	59.86	.4		.0	.02
9	.84	.84		0		.04	.88	.85	3			.01
10	.89	.83	6		.05		.84	.84		0		.01
11	.84	59.82	2		.00		.84	.82	2		0	
12	~~.82~~	59.82										
13		.81										
14		.80										
15		.79										
16	59.80	.79	1		.13		59.67	.75	8		.04	
17	.72	.78		6		.02	59.74	.73	1		.05	
18	.75	.78		3	.02		.73	.73		0	.05	
19		.78										
20		.77										
21	.75	.76		1	.04		.71	.73		2	.03	
22	.77	.76	1			.01	.78	.73	5		.03	
23		.75										
24		.74										
25	.77	.73	4		.06		.71	.73		2	.00	
26	.74	.73	1		.08		.66	.71		5	.02	
27		.72										
28		.67										
March 1	.67	.62	5	5	.01		.66	.65	1			.03
2	.60	.58	2			.02	.62	.62		0		.04
3		~~.62~~ 53										
4		.~~58~~ 4										
5		.43										
6		.48.39										
7		.34										
8	.29	59.29		0	~~.05~~	.07						
9	.32	.28	4		.05		.27	.27		0	.01	
10		.25										
11	.32	.25	7		.01		.30	.27	4			.02
12		.24										
13		.22										
14		.21										
15	.14	59.20		6		.09	.23	.27		4		.07
16	.25	.20	5		.04		.21	.27		6		.07
17		.20										
18	.17	.20		3		.07	.24	.27		3		.07
19	.18	.20		2		.06	.24	.27		3		.07
20		.20										
21		.20										

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e A

	T. C	Plotted	Errati		(A-a) creep		T. C	Plotted error	Errati		$P_a - P_A$	
22	59.29	.20	9		.05		59.24	.27		.3	.	.07
23		.20										
24		.20										
25		.20										
26	59.18	59.20	~~[illegible]~~	2		.10	59.28	59.27	1			.07
27		.24										
28	59.26	.29		3		.04	59.22	59.27		5	.02	
29	.35	.33	2		.05		.30	.31		1	.02	
30		.33										
31	.39	.34	5	~~[illegible]~~	.00		.39	.39	0			.05
April 1	.32	.34		2		.07	~~.39~~ .39	.43		4		.09
2	.37	.35	2			.07	.44	.42	2			.07
3	~~.32~~	.35	~~[illegible]~~	~~3~~								
4	.32	.35		3		.02	.34	.40		6		.05
5		.36										
6		.36										
7	.36	.37		1		.04	~~.46 .32~~ .40	.38	2			.01
8		.37										
9		.37										
10		.38										
11	.38	59.38	0 0		.05		.33	.35		2	.03	
12		.36										
13		.34										
14	.37	.33	4		.06		.31	.32		1	.01	
15	.26	.31		5	.08		~~.28~~ .34	59.31	3			0
16		.29										
17		.27										
18		.25										
19		.24										
20	.16	.22		6	.0	.05	.21	.21	0		.01	
21		.20										
22		.18										
23	.20	.16	4			.01	.21	.16	5			0
24		.15										
25		.13										
26		.11										
27		.09										
* 28	.04	.07		3	omit							
29	.05	59.05	0		.04		.01	.07		6		.02
30	.04	.05		1		.04	.08	.07	1			.02
May 1		.05										
2	.04	.05		1		.06	.10	.07	3			.02

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*: one clock star only

C A

1921	T. C	Plotted	Errati		(A-a) error		T. C error	Plotted error	Errati		
3		.05									
4	59.05	.05	0		.01		59.04	59.07		3	.02
5		.07									
6		.09									
× 7	59.16	59.11	5		omit						
8		.13									
× 9	59.07	.15		8	omit						
10	59.21	.17	4			.02	59.23	59.23	0		.06
11		.19									
12	59.30	.21	9		.02		.28	.28	0		.07
13	59.33	.23	10		.04		.29	.30		1	.07
14		.25									
15		.27									
16		.29									
17	59.27	.31		4		.07	.34	.36		2	.05
18		.33									
19	59.41	.35	6		.02		.39	.40		1	.05
20	59.37	59.37	6			.06	.43	.42	1		.05
21		.37									
22		.37									
23	59.42	.37	5		.04		.38	.40		2	.03
24		.37									
25		.37									
26	59.36	.38		2		.04	.40	.38	2		0
27		.38									
28		.38									
29		.38									
30		.39									
31	59.40	.39	1		.04		.36	.34	2		.05
June 1		.39									
2	59.38	.39		1	.12		.26	.33		7	.06
3	59.33	.39		6		.02	.35	.32	3		.07
4		.39									
5		.40									
6	59.49	.40	9		.13		.36	.30	6		.10
7	59.34	.40		6	.07		.27	.29		2	.11
8		.40									
9		.40									
10		59.40									
11	59.40	.42		2		.06	.46	0.46	0		.04
12		.44									
13		.46									

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l | A

	T.C	Plotted error	Erratic	(A-a) correc	T.C	Plotted error	Erratic	
14	59.49	.48	1	.01	59.48	.47	1	.01
15		.51						
16	59.57	.53	4	.06	.51	.51	0	.02
17		.55						
18		59.57						
19		.59						
20		.62						
21		.64						
22		.66						
23	59.68	.68	0	.02	59.66	59.65	1	.03
24		59.70						
25	59.65	.65	0	.12	59.53	.60	7	.05
26		.60						
27	59.54	.55	1	.04	.58	.55	3	.00
28	59.49	59.49	0	.01	.48	.52	4	.03
29		.52				0.50		
30		.55						
July 1	59.60	.58	2	.08	.52	.52	0	.06 Ag
2		.61						
3		.64						
4	59.67	59.67	0	.14	.53	.55	2	.12
5		.66						
6	59.62	.64	2	.04	.58	.58	0	.06
7		.63						
8	59.65	.61	4	.01	.64	.61	3	00
9		.60						
10		.59						
11		.57						
12	59.61	.56	5	.08	.53	.53	0	.03
13	59.51	.54	3	.02	.49	.50	1	.04
14		.53						
15		.52						
16		.50						
17		.49						
18		.47						
19		.46						
20	59.40	.45	5	.06	.36	.36	0	.09
21		.43						
22		.42						
23	59.48	.40	8	.08	.40	.36	4	.04
24		.39						
25	59.37	59.37	0	.02	.39	.36	3	.01

	l				A			
	T.C.	Plotted error	Erratic	(A-a) error c/f	T.C error	Plotted error	Erratic	/
26	59.39	.37	.2	.06	.33	.35	2	.02
27		.37						
28		.37						
29		.37						
30		.36						
31		.36						
August 1		.36						
2	59.39	.36	3	.04	59.35	.33	2	.03
3		.36						
4		.35						
5		.35						
6		.35						
7		.35						
8	59.35	59.35	0	.04	59.31	59.31	0	.04
9		.37						
10		.39						
11		.42						
12		.44						
13		.46						
14		.48						
15	59.44	.50	6	.01	59.43	.45	2	.05
16		.53						
17		.55						
18	59.62	.57	5	.07	59.55	.51	4	.06
19		.59						
20		.62						
21		59.65						
22		.66						
23		.67						
24		.68						
25	59.70	.69	1	.05	59.65	.65	0	.04
26		.70						
27		.71						
28		59.72						
29	59.72	.70	2	.16	59.56	.55	1	.15
30	59.67	.68	1					
31		.66						
Sept 1	59.60	.64	4	.01	59.49	.49	0	.15
2	59.59	.62	3	.08	59.51	.50	1	.12
3		.60						
4		.58						
5	59.58	.56	2	.02	59.56	.53	3	.03

	l				A			
	T.C error	Plotted error	Errata	(A-a) creep	T.C	Plotted	Errata	
6		.54						
7	59.52	59.52	0	.01	59.51	.54	3	.02
8		.62						
9		.72						
10	59.95	.82	13	20	59.75	.75	0	.07
11		.93						
12	0.00	0.03	3	14	59.86	.86	0	.17
13		0.13						
14	.27	.23	4	17	0.10	.10	0	.13
15	.36	.33	3	18	.18	.23	5	.10
16	.43	0.43	0	.01	.42	0.39	3	.04
17		.47						
18		.51						
19		.55						
20	.59	0.59	0	.08	.51	0.61	0	.08
21	.56	.54	2	~~[illegible]~~				
22		.49						
23	.45	0.45	0	.12	.33	.40	7	.05
24	.58	.55	3	.20	.38	.35	3	.20
25		.65						
26	.69	.75	6	.16	.53	.53	0	.22
27	.85	0.85	0	.20	.65	.63	2	.22
28		.82						
29		.79						
30	.80	.76	4	.17	.63	.63	0	.13
Oct. 1	.80	.73	7	.16	.64	.64	0	.09
2		.70						
3		.67						
4		.64						
5		.61						
6		.58						
7		.55						
8		.52						
9	.51	.49	2 ~~3~~	.13	.38	.38	0	.11
10	.45	.46	1	.12	.33	.35	2	.11
11		.43						
12	.37	.40	3	.11	.26	.28	2	.12
13	~~.37~~	.37						
14	.32	.34	2 ~~3~~	.21	.11	.20	9	.14
15	.31	0.31	0	.14	.17	.17	0	.14
16		.23						
17		.15						

	e T.C error	e Plotted error	e Erratic	(A–a) error	A T.C error	A Plotted error	A Erratic	$P.E_e - P.E_A$
18	0.10	0.07	3	.08	.02	.00	2	.07
19	59.99	59.99	0	.06	59.93	.93	0	.06
20	59.89	.99	10	.01	.88	59.88	0	.11
21		.99				.88		
22	0.06	.99	7	.17	.89	.88	1	.11
23		.99				.88		
24	59.98	.99	1	.13	.85	.88	3	.11
25	.01	.00	1	.16	.85	.88	3	.12
26		.00				.88		
27	0.00	.00	0	.14	.86	.88	2	.12
28	59.98	.00	2	.10	.88	.88	0	.12
29	.97	.00	3	.13	.84	.88	4	.12
30		.00				.88		
31	.95	.00	5	.11	.84	.88	4	.12
Nov 1		.00				.88		.11
2	0.05	.00	5	.15	.90	59.88	2	.12
3		.99				.86		
4	59.97	.97	0	.14	59.83	59.84	1	.13
5		.96						
6		.94						
7	.91	.93	2	.21	59.70	59.80	10	.13
8	.79	.91	12	.08	.71	.78	7	.13
9	.86	.90	4	.11	.75	.77	2	.13
10	.87	.89	2	.15	.72	.75	3	.14
11		.87						
12	59.82	.86	4	.07	59.75	.71	4	.15
13		.85						
14		.83						
15		.81						
16		.80						
17		.78						
18		.77						
19		.75						
20		.74						
21		.72						
22		.71						
23	59.73	.69	4	.24	59.49	59.52	3	.17
24		.67						
25	59.65	.66	1	.14	59.51	.52	1	.14
26	59.65	.64	1	.07	59.58	.52	6	.12
27		.63						
28		.61						

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	T.C	Plotted error (l)	Errats	(A-a) corr	T.C error (A)	Plotted error	Errats	
29	59.63	.60	3	.13	59.50	.52	2	.08
30	59.69	.58	11	.11	.58	.52	6	.06
Dec 1		.56						
2		.55						
3	59.56	59.53	3	.09	59.47	.52	5	.01
4		.52						
5	59.51	.50	1	.02	.53	.52	1	.02
6	59.53	.49	4	.02	.51	.52	1	.03
7		.47						
8	59.47	.45	2	.01 [illegible]	.486	.48	2	.07 .03
9	.53	.44	9	6	.487	.46	1	.02
10		.42						
11		.41						
12	.37	.39	2	4	.33	.39	6	0
13	.40	.37	3	1	.39	.37	2	0
14	.32	.36	4	2	.30	.35	5	.01
15	.35	.35	0	1	.34	.33	1	.02
16	.36	59 .34	2	6	.30	.31	1	.03
17	.43	.42	1	5	.38	.28	10	.14
18		.34						
19	.29	.37	8	.17	.12	.24	12	.13
20	.50	.46	4	.01	.51	.46	5	0
21	.57	.55	2	.08	.49 .49	.52	3	3
22	.68	.62	6	.01	.67	.67	0	.05
23	.75	.71	4	.067	.68	.73	5	.02
24		.79				.79		
25		.88				.85		
26		.96				.91		
27		.04				.97		
28	0.05	.12	7	.01	0.04	.04	0	.08
29	.21	.20	1	.07	.14	.12	2	.08
30		.29						
31		.37						
Jan 1								
2								
3								
4								
5								
6								
7								
8								
9								

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	e				A			
	T.C. error	Plotted error	Erratic	(A-a) corr?	T.C. error	Plotted error	Erratic	
Jan 0								
1		0.04						
2		59.98						
3		.92						
4		.87						
5		.81						
6		.76						
7		.70						
8	59.68	.64	4	.01	59.69			
9		.59						
10		.53						
11		.48						
12		.42						
13		.36						
14		.31						
15	59.27	59.27	0	.12	59.15	59.20	5	.07
16		.31						
17	59.45	.35	10	.13	59.32	.28	4	.07
18		.39						
19	59.33	.43	10	.04	59.29	.35	6	.08
20		.47						
21	59.47	.50	3	.02	59.45	.44	1.	.06
22		.54						
23		.58						
24	59.58	.62	4	.07 omit				
25		.66						
26	59.71	.70	1	.07	59.64	.62	2	.08
27		.74						
28		.78						
29		.82						
30	59.85	59.85	0	.11	59.74	.76	2	.09
31		.85						
Feb 1		.85						
2	59.78	.85	7	.05	59.83	.76	7	.09
3		.85						
4	59.84	.85	1	.07	59.77	.76	1	.09
5	59.79	59.86	7	.06	59.73	.75	2	~~.09~~ .11
6	59.88	.86	2	.05	59.83	.75	8	.11
7	59.97	.86	11	.15	59.82	.75	7	.11
8		.86				.74		
9		.86				.74		
10	59.73	.86	.13	.11	59.62	.74	.128	.12

	l				A			
	T.C error	Plotted error	Erratic	(A-a) cosec φ	T.C error	Plotted error	Erratic	
11	59.72	.86	14	.10	59.62	.73	11	.13
12		.86						
13	.81	.86	5	.14	59.67	.73	~~2~~ 6	~~.21~~ .13
14		.86						
15		.86						
16	.82	.86	4	.15	.67	.72	5	.14
17	.76	.86	10	.08	.68	.72	4	.14
18		.86						
19		.86						
20		.87						
21	.92	.87	5	.13	.79	.71	8	.16
22		.87						
23		.87						
24	.79	.87	8	.01	.78	.71	7	.16
25	.93	.87	6	.13	.80	.70	10	.17
26	.83	.87	4	.08	.75	.70	5	.17
27	59.90	59.87	3	.10	.80	59.70	10	.17
28		.87						
29		.87						
March 1		.87						
2	59.91	59.87	4	.06	.85	.81	4	.06
3		.91						
4		.94						
5		59.98						
6		0.02						
7		.06						
8	0.09	.09	0	.14	.95	.99	4	.10
9	.08	.13	5	.10	.98	.02	3	.11
10		.17						
11	.11	.20	9	.01	.10	.08	2	.12
12		.24						
13	.16	.28	12	.05	.13	.13	2	.15
14		.31						
15		.35						
16		.39						
17		0.43						
18	.40	.46	6	.07	.33	.30	3	.16
19		.50						
20		.54						
21		.57						
22	.60	0.60	0	.12	.48	.45	3	.15
23		.55				0.48		

	T.C	Plotted Error	l Erratic	(A-a) correct	T.C error	A Plotted error	Erratic	
24		.51						
25		.46						
26	0.47	.41	6	.06	.41	0.35	6	.06
27		.36						
28		.32						
29		.27						
30		.22						
31		.18						
April 1		.13						
2		.08						
3		0.04						
4		59.99						
5		.94						
6		.89						
7	59.81	.85	4	.11	59.70	59.70	0	.15
8		.80						
9		59.76						
10		.77						
11		.79						
12		.80						
13		.82						
14		.83						
15		.84						
16	59.80	.86	6	.06	59.74	.81	7	.05
17	59.83	.87	4	.08	59.75	.82	7	.05
18		.89						
19		.90						
20		.91						
21	59.99	.93	6	.12	59.87	88	1	.05
22	59.99	59.94	5	.09	59.90	.90	0	.04
23		59.96						
24		.97						
25		59.98						
26		0.00						
27		.01						
28		.03						
29	.03	.04	1	.05	59.98	.97	1	.07
30.	0.14	.09 5	9	.13	0.01	.98	3	.07
May 1		.06						
2		.08			.	00		
3	0.11	.09	2	.11	00	0 0	0	.09
4	.01	~~.09~~ .11	10	.06	59.95	.00	5	.11

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	e				A			
	T.C	Plotted error	Erratic	(A–a) cosec φ	T.C error	Plotted error	Erratic	
5		.12						
6		.13						
7	0.16	.15	0	.20	59.95	.00	5	.15 .20
8		.16						
9		.18						
10	0.15	.19	4	.14	0.01	.00	1	.19
11		.17						
12		.15						
13	0.08	.14	6	.08	.00	.00	0	.14
14		.12						
15	0.14	.10	4	.12	.02	.00	2	.10
16		.08						
17		.06						
18		.05						
19	.02	.03	1	.02	.00	.00	0	.03
20	59.97	0.01	4	.08	59.89	.96	7	.05
21		59.98						
22	59.89	.97	8	.05	.84	.88	4	.09
23		.96						
24	59.91	.94	3	.12	.79	.82	3	.12
25		.92						
26		.90						
27		.88						
28	59.67	59.86	19*	.02	59.69	59.70	1	.16
29		.88						
30		.90						
31		.91						
June 1		.93						
2	59.87	.95	8	.06	59.81	.79	2	.16
3		.97						
4	0.01	59.99	2	.18	59.83	.83	0	.16
5		0.01						
6		.04						
7	0.06	0.00	6	.09	59.97	.92	5	.08
8	.08	.03	5	.14	59.94	.95	1	.08
9	.00	.01	1	.08	59.92	.97	5	.04
10		59.98						
11		.95						
12		.92						
13		.90						
+14	59.79	.87	8	.18	59.61	59.61	0	.26
+15	59.90	.85	5	.20	59.70	.63	7	.22

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

* Single polar star and three clock stars

	C				A				
	T.C	Plotted error	Erratis	(A-a) creep	T.C error	Plotted error	Erratis		
16	.78	.82	4	~~.23~~ .12	59.66	.65	1	17	
17	.83	59.80	3	.23	59.60	.67	7	.13	#
18		.80							
19	.88	.80	8	.13	59.75	.70	5	.10	
20		.80							
21		.80							
22		59.80							
23	59.76	.83	7	.01	59.75	.76	1	.07	
24		.86							
25	59.95	.90	5	.17	59.78	59.79	1	.11	
26	59.96	.93	3	.11	59.85	.83	2	.10	
27		59.96							
28		0.00							
29	0.02	.03	1	.06	59.96	.95	1	.08	
30		.06							
July 1		.10							
2		.13							
3	0.20	.16	4	.08	0.12	.12	0	.04	
4		.20							
5		.23							
6	0.22	.26	4	.02	0.20	0.22	2	.04	
7		.30							
8		.33							
9		.36							
10		0.40							
11		.36							
12		.31							
13		.27							
14		.22							
15	0.23	.18	5	.05	0.18	0.18	0	00	
16		.14							
17	.12	.09	3	.02	0.14	0.16	2		.07
18		0.04							
19		59.99							
20	59.99	.94	5	.02	59.97	.97	0		.03
21	59.97	89	8	.02	.95	.90	5		.01
22		.85							
23		.80							
24	59.74	.76	2	.06	68	.72	4	.04	
25		.71							
26		59.66							
27	59.61	.67	6	.04	59.57	59.57	0	.10	

	l				A			
	T.C error	Plotted error	Erratics	(A-a) correct	T.C error	Plotted error	Erratics	
28	59.69	.68	1	.11	59.58	.58	0	.10
29	59.70	.69		.11	59 59	.60	1	.09
30		.70						
31		.72						
August 1		.73						
2	59.76	.74	2	.01	59.75	.68	7	.06
3	59.77	.75	2	.06	59.71	59.70	1	.05
4		.76						
5		.78						
6		.79						
7		.80						
8		.81						
9	59.87	.82	5	.09	59.78	.78	0	.04
10		.83						
11		.84						
12	59.90	.86	4	.08	59.82	.82	0	.04
13		.87						
14	59.91	.88	3	.06	59.85	.85	0	.03
15		.89						
16		.90						
17		.91						
18		.92						
19		.93						
20	59.93	.94	1	.02	59.91	.91	0	.03
21		.95						
22		.96						
23		.97						
24		.98						
25		59.99						
26		.01						
27		.02						
28		.03						
29		.04						
30		.05						
31	.04	.06	2	.01	0.03	.03	0	.03
Sept 1		.07						
2		.08						
3		.09						
4	.10	0.10	0	.02	0.08	.08	0	.02
5		.15						
6		.20						
7	.29	.25	4	.08	0.21	.25	4	.00

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8	.40	.31	9	.05	.35	0.35	0	~~.04~~	.04
9		.36							
10		.41							
11		.46							
12		.52							
13	.58	0.58	0	.17	.41	.41	0	.17	
14		.57							
15	.52	.57	5	.08	.44	.44	0	.13	
16	.53	.56	3	.13	.40	.45	5	.11	
17	.55	.55	0	.09	.46	0.46	0	.09	
18		0.55							
19		0.41							
20		.27							
21	.07	.13	6	.08	59.99	59.99	0	.14	
22	.00	0.00	00	.11	59.89	.89	0	.11	
23	.09	Tempre disturbed							
24	.03			.04	0.07	0.07	0		
25	.23	0.23	00	.11	.12	0.12	0	.11	
26		.28							
27		.33							
28	.40	.37	3	.17	.23	.23	0	.14	
29		.42							
30	.47	0.47	0	.17	.30	.30	0	.17	
Oct 1		.43							
2		.39							
3		.36							
4		.30							
5		.26							
6	.20	.22	2	~~.09~~ .10	.10	.15	5	.07	
7	.14	.18	4	.04	.10	.12	2	.06	
8	.20	.13	7	.06	.14	.10	4	.03	
9		.09				0.08		.01	
10		.05							
11		.01							
12	59.98	59.95	3	~~.09~~ .10	59.~~890~~ 88	59.89	1	.06	
13	59.92	59.957	5	0	59.92	.91	1	.06	
14		.98							
15		0.00							
16		.01							
17		.03							
18	59.97	.04	4	.05	0.02	0.99	3	.05	
19	.03	.05	2	.05	59.98	.01	3	.04	

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20		.07						
21		.08						
22		.10						
23	.04	.12	8	.05	59.99	.06	7	.06
24		.14						
25	.10	.16	6	.00	.10	.08	2	.08
26	.17	.18	1	.10	.07	.09	2	.09
27		.19						
28	.19	.21	2	.07	.12	.11	1	.10
29	.25	.23	2	.07*				
30	.23	.25	2	.12	.11	0.12	1	.13
31		.26						
Nov 1		.28						
2		.30						
3		.29						
4		.27						
5	.26	.25	1	.08	.18	.13	5	.12
6		.24						
7		.22						
8	.18	.21	3	.04	.14	.14	0	.07
9	.17	.19	2	.07	.10	.13	3	.06
10	.16	.17	1	.08	.08	.13	5	.04
11	.14	.16	2	.06	.08	.12	4	.04
12	.12	.14	2	.02	.10	.12	2	.02
13	.08	.13	5	~~.09~~ .01 ~~.08~~	.07	.12	5	.01
14		.11				.11		
15		.09				.10		
16		.08				.09		
17	.06	.06	0	~~.03~~ ~~.10~~ 12	.18	.09	9	.03
18		.05				0.08		
19	.11	.05	6	.10	.01	.05	4	0
20	.04	.04	0	.01	.05	.02	3	.02
21		.03				.99		
22	.06	.03	3	.14	59.92	.96	4	.07
23	.07	.02	5	.09	.98	.9~~8~~3	5	.09
24	59.98	.01	3	.00	.98	.90	8	.11
25	0.01	0.01	0	.25	.76	.86	10	.15
26		59.99						
27		.96				.8		
28		.94						
29		.91						
30		.89						

(677) Wt 6085-54 10m 2/16 M & G Ltd G 14

* adopted

Dec 1	59.84	.86	2	.11	59.73	.77	4	.09
2	.84	.84	0	~~13~~ .08	~~57.71~~ 59.76	.75	1	.09
3		.81						
4	.82	.79	3	.19	~~72~~ .69	.71	2	.08
5		.76						
6		.74						
7		.71						
8	.68	59.68	0	.10	.58	.64	6	.04
9		.68						
10		.68						
11		.69						
12		.69						
13		.69						
14	.76	.70	6	.13	59.63	.65	2	.05
15		.70						
16	.63	.70	7	.01	.64	.65	1	.05
17	.65	.71	6	.02	.63	.65	2	.06
18		.71						
19		.71						
20		.72						
21	.67	.72	5	.05	.62	.66	4	.06
22	.75	.72	3	.10	.65	.67	2	.05
23	.73	59.73	0	.08	.62	.67	2	.06
24		.77						
25		.80				59.67		.13
26		.83						
27	.83	.86	3	.10	.73	.74	1	.12
28		.89						
29		.92						
30	59.98	59.96	2	.11	.87	59.87	0	.09
31	0.07	0.00	7	.11	.96			

0	59.56	59.56	0					
1		.61						
2	59.59	.66	1	.02	59.57			
3		.71						
4		.76						
5		.81						
6	59.92	.85	7	.14	59.78	59.78	0	.07
7		.90						
8		.95						
9		0.00						
10		.05						
11		.10						
12		.15						
13		.20						
14		.25						
15		.30						
16	(.43)	.34	9	.12	.31	.30	1	.04
17	.37	.39	2	.02	.35	.35	0	.04
18		.44						
19		.49						
20		.54						
21		.59						
22	.64	0.64	0	.06	.58	0.58	0	.06
23		.76						
24		.68						
25	.60	.60	0	.17	.43	.38	5	.22
26		.52						
27		.44						
28		.36						
29		.28						
30		.20						
31		0.12						
Feb 1		0.04						
2		59.96						
3		.88						
4		.80						
5		.72						
6		.64						
7		.56						
8	59.48	59.48	0	.12	59.36	59.36	0	.12
9		Temp=						
10	59.42	changing						

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

11								
12	59.32	Tempre						
13		changing						
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24	0.04							
25								
26								
27								
28	0.59	0.59		.11	.48			
h 1		.72						
2		.79						
3	0.65	.73	8	.06	.59	0.59	0	.18
4		.67						
5	0.59	.61	2	.12	.47	.49	2	.14
6		.55						
7		.49						
8		.43						
9		.36						
10		.30						
11		.24						
12		.18						
13		.12						
14		.06						
15		0.00						
16		59.94						
17	59.90	.88	2	.01	59.91	.83	8	.05
18		.81						
19		.75						
20		.69						
21		.63						
22	59.55	.57	2	.02	59.53	.56	3	.01
23		59.51						
24		59.51						

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

25	59.48	59.50	2	.08	59.40	59.40	0	.10
26		.52						
27		.53						
28		.55						
29	59.55	.56	1	.05	59.50	.47	3	.09
30		.58						
31		.60						
l 1		.61						
2		.63						
3		.64						
4	59.61	.66	5	.02	59.53	59.56	7	.10
5		.68						
6		.69						
7		.71						
8	59.74	.72	2	.04	59.70	66	4	.06
9		.74						
10		.76						
11		.77						
12	59.79	.79	0	.01	59.78	.78	0	.01
13		.80						
14		.82						
15		.84						
16		.85						
17		.87						
18		.89						
19		.90						
20	59.86	.92	6	.10	59.96	59.99	0	.07
21		.93						
22		.95						
23		.96						
24		59.98						
25		0.00						
26	0.09	.05	4	.10	59.99	.99	0	.06
27		.09						
28		.08						
29		.06						
30		.05						
ay 1		.04						
2	0.06	.02	4	.06	.00	.99	0	.03
3		.01						
4		59.99						
5		.98						

(677) Ẇt 6035-54 10m 2/16 M & G Ltd G 14

6		59.97						
7		.96						
8		.95						
9		.93						
10	59.92	.92	0	.04	59.88	.87	1	.05
11		.91						
12		.90						
13		.89						
14	59.88	.87	1	.10	59.78	59.8.0	2	.07
15		59.83						
16		.79						
17		.75						
18		.72						
19	59.62	.68	6	.02	59.60	.57	3	.11
20	59.56	.64	8	.11	59.45	59.47	2	.19
21		.60						
22		.57						
23		.59						
24		.49						
25		.45						
26	59.43	.41	2	.06	59.49	.49	0	.08
27		59.49						
28		.56						
29		.62						
30		.69						
31		.75						
June 1		.81						
2	59.88	.88	0	.06	59.94	.90	4	.02
3		59.94						
4		0.01						
5		.07						
6		.13						
7		.20						
8		.26						
9	0.33	.36	3	.06	0.27	0.30	3	.06
10		.26						
11		.24						
12		.21						
13	0.18	.19	1	.00	0.18	.14	4	.05
14		.16						
15		.13						
16		.11						

(677) Wt 6035-54 10m 2/16 M & G Ltd **G 14**

17		0.08						
18		.06						
19	59.98	.04	.06	,11	59.87	.90	3	.14
20		0.00						
21	59.89	59.98	9	.07	59.82	59.82	0	.16
22		.95						
23		.93						
24		.90						
25	59.91	.87	4	.16	59.75	.74	1	.13
26		.85						
27		.82						
28	59.79	.80	1	.13	59.66	.66	0	.14
29		.77						
30	59.78	.74	4	.18	59.60	59.60	0	.14
July 1		.72						
2		.69						
3		.67						
4		.64						
5		.61						
6		.59						
7		59.56						
8		.54				59.41		
9	59.53	.56	3	.02	59.51	59.44	4	.12
10		.58						
11		.60						
12	59.59	.62	3	.05	59.54	59.54	0	.08
13		.63						
14		.65						
15		.67						
16	59.69	.69	0	.07	59.62	.63	1	.06
17		.71						
18		.73						
19		.75						
20		.77						
21	59.81	.80	1	.02	59.79	.80	1	00
22		.81						
23		.82						
24		.84						
25	59.89	59.86	3	.01	59.90	.92	2	.06
26		.88						
27		.89						
28	59.89	.90	1	.17	0.06	0.00	6	.10

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

29		59.91						
30	59.99	.93	6	.02	59.97	59.98	1	.05
31		.94						
August 1		.95						
2		.96						
3		.97						
4		.98						
5	59.96	59.99	3	.04	59.92	.92	0	.07
6	0.01	0.00	1	.06	59.95	.91	4	.09
7		.01						
8		.02						
9	59.96	.04	8	.11	59.85	.87	2	.17
10		59.87						
11		.88						
12		.90						
13		.91						
14	59.81	.93	12	.07	59.88	.82	6	.11
15		.95						
16	59.93	.96	3	.05	59.88	.86	2	.10
17		.98						
18		59.99						
19	59.98	0.01	3	.08	59.90	.90	0	.01
20	0.04	.03	1	.13	59.91	.92	1	.11
21		.04						
22		.06						
23		.07						
24		.09						
25		.11						
26		.12						
27	0.24	.14	10	.25	59.99	.03	4	.11
28		.15						
29	(0.07)	.17	10	.01 .04	.11	.07	4	.10
30		.19						
31		.20						
Sept 1		.22						
2	.23	.23	0	.16	.07	.13	6	.10
3		.25						
4	.29	.27	2	.12	.17	.17	0	.10
5	0.37	.28	9	.20	.17	0.19	2	.09
6		Tempre changing						
7								
8								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19	0.26			.22	.04			
20								
21								
22	0.17			.32	59.85			
23								
24								
25								
26	0.09			.16	59.86			
27	59.93			.13	59.80			
28								
29								
30								
1								
2	59.82			.23	59.59	59.58	1	
3		59.81						
4		.87						
5		.93						
6	59.94	59.99	5	.05	59.89	.83	6	.16
7		0.06						
8	.00	.12	12	.05	59.95	.98	3	.14
9		.18						
10		.24						
11		.30						
12		.36						
13		.42						
14	0.59	.48	11	.24	.0.35	.34	1	.14
15	0.56	.54	2	.18	0.38	.39	1	.15
16	0.64	.60	4	.19	0.45	.45	0	.15
17		.67						
18		.73						
19		.79						
20		.85						

21	.93	0.95	2	.14	59.79	0.78	1	.17
22		.93						
23		.92						
24		.90						
25	0.89	.89	0	.11	.78	0.78	0	.11
26		.88						
27	.88	.86	2	.23	.65	.69	4	.17
28	0.88	.82	6	[illegible]	[illegible]			
29		.76				.59		
30		.69						
31		.63				.		
o. 1		.57						
2		.51						
3		.45						
4		.38						
5		.32						
6		.26						
7		.20						
8	0.14	.14	0	.01	.13	.13	0	.01
9		.07						
10		0.01						
11		59.95						
12								
13	0.30			.18	59.92	59 92	0	
14	0.23	0.20	3	.24	59.99	.94	5	.26
15	0.19	.20	1	.22	59.97	.96	1	.24
16		.20						
17	0.16	.20	4	.08	0.08	.00	8	.20
18		.20						
19		.20						
20	0.12	.21	0	.06	.06	0.06	0	.15
21		.21						
22		.21						
23		.21						
24		.21						
25		.21						
26		.21						
27		.21						
28		.22						
29	0.23	.22	1	.06	.17	.13	4	.09
30		.22						
De 1	0.25	.22	3	.08	.17	.14	3	.08

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2		0.22						
3		.22						
4	0.18	.22	4	.07	.11	0.16	5	.06
5		.20						
6		.22						
7		.24						
8		.26						
9		.29						
10		.31						
11	0.28	.33	5	.02	.26	.26	0	.05
12		.35						
13		.37						
14		.39						
15		.41						
16	0.47	.43	4	.11	.36	.33	3	.10
17	0.47	.45	2	.10	.37	.34	3	.11
18		.47						
19		.50						
20		.52						
21		.54						
22	.55	.56	1	.17	.38	.41	3	.15
23	.54	.58	4	.11	.43	0.42	1	.16
24		.49						
25		.43						
26		.38						
27	0.31	.32	1	.18	.13	.16	3	.16
28		.26						
29	.13	.20	7	.08	.05	0.05	0	.15
30		.14						
31	0.02	.09	7	.06	59.96	59.96	0	.13

	T.C error	Plotted Error	Erratic	A-a correcn	T.C. error	Erratic	Plotted error	$P_C - P_A$
Jan 0								
1	58.99	58.97	·2	.17	58.87	58.82	0	.15
2	.94	58.99	5	.11	58.83	.84	1	.15
3						.85		
4	59.00	59.04	4	.11	58.89	.85	4	.19
5								
6								
7	59.07	59.10	3	.19	58.88	.92	4	.18
8	59.13	.13	0	.18	58.95	58.94	1	.19
9	59.05	59.05	0	.17	58.88	.88	0	.17
10								
11								
12	58.80	58.80	0	.18	58.62	58.62	0	.18
13								
14								
15	58.73	(changing)		.17	58.56	.60	4	
16	58.79	58.79	0	.20	58.59	.59	0	.20
17	58.82	58.88	6	.18	58.64	.70	4 6	.18
18				~~.18~~				
19								
20								
21								
22								
23								
24								
25								
26								
27								
28	59.91	59.91	0	.11	59.80	59.80	0	.11
29								
30								
31								
Feb 1			~~.006~~					
2								
3								
4								
5								
6								
7								
8								
9								
10								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

25								
26								
27								
28								
29								
30								
31								
April 1	0.31	0.31	0	.07	.24	0.23	1	.08
2								
3								
4								
5								
6	0.48	.49	1	.10	.38	.42	4	.07
7								
8								
9	0.60	0.60	0	.08	.52	0.52	0	.08
10								
11								
12								
13	0.43	.41	2	.01	.44	.44	0	.03
14								
15	0.28	0.31	3	~~10~~ .11	.39	0.39	0	.08
16								
17								
18								
19								
20								
21								
22	59.95	59.98	3	.05	0.00	.02	2	.04
23								
24								
25	59.85	59.83	2	.01	.86	.87	1	.04
26	59.82	59.78	4	.01	.83	.83	0	.05
27								
28								
29								
30	59.67	59.59	8	.04	.63	.63	0	.04
May 1								
2								
3								
4								
5								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18	59.14	59.18	4	.04	59.10	59.10	0	.08
19	59.16	59.23	7	.02	59.18	.17	1	.06
20								
21	59.26	59.32	6	.07	59.33	.29	4	.03
22								
23								
24								
25								
26	59.40 ※	59.65	15	.18	59.58	.54	1	.02
27								
28	59.66	59.64	2	00	59.66	59.67	1	.03
29								
30	59.75	59.75	0	.02	59.73	.78	5	.03
31								
June 1								
2	59.93	59.92	1	.02	59.91	.93	2	.01
3								
4	59.99	0.03	4	.04	0.03	0.03	0	0
5	0.11	.09	2	.01	~~.08~~ .10	.10	0	.01
6								
7	0.25	0.20	5	.01	.24	.22	2	.02
8								
9								
10								
11								
12								
13								
14								
15								
16								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

※: Single reading

17						0.60			
18									
19									
20									
21									
22	0.65	0.61	4	.16	.49	.40	9	.21	
23									
24									
25									
26									
27									
28									
29									
30									
31									
July 1									
2	0.13	0.08	5	.26	59.87	.97	10	.11	
3									
4									
5									
6	59.87 (1)	59.87	0	.05	59.92	.82	x10	.05	
7									
8									
9	59.91	59.91	0	.12	59.79	.79	0	.14	
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24	59.69	59.65	4	.06	59.63	59.63	0	.02	
25		.65	-						
26	59.73	59.80		7 .04	59.77	.85	8		.05
27	59.90	59.95		5 00	59.90	.98	8		.03

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(1) single folio

28								
29	0.21	.25	4	.04	0.25	.25	0	00
30		0.40						
31								
August 1								
2								
3								
4								
5								
6								
7								
8								
9	0.11	.07	4	.06	0.05	0.05	0	.02
10								
11								
12								
13	59.93	59.94	1	.05	59.98	59.93	5	.01
14	59.93	59.90	3	.02	59.91	.90	1	00
15	59.85	59.87	2	.02	59.87	.87	0	00
16								
17								
18								
19								
20								
21								
22	59.59	59.64	5	.04	59.63	.70	7	.06
23								
24								
25								
26								
27						59.52		
28	59.58	59.53	5	.07	59.65	.57	8	.04
29								
30	59.65	59.62	3	.01	59.66	.66	0	.04
31								
Sept 1								
2								
3								
4								
5								
6								
7								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

28								
29	0.21	.25	4	.04	0.25	.25	0	00
30		0.40						
31								
Augt 1								
2								
3								
4								
5								
6								
7								
8								
9	0.11	.07	4	.06	0.05	0.05	0	.02
10								
11								
12								
13	59.93	59.94	1	.05	59.98	59.93	5	.01
14	59.93	59.90	3	.02	59.91	.90	1	00
15	59.85	59.87	2	.02	59.87	.87	0	00
16								
17								
18								
19								
20								
21								
22	59.59	59.64	5	.04	59.63	.70	7	.06
23								
24								
25								
26								
27						59.52		
28	59.58	59.53	5	.07	59.65	.57	8	.04
29								
30	59.65	59.62	3	.01	59.66	.66	0	.04
31								
Sept 1								
2								
3								
4								
5								
6								
7								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18	.42	0.52	10	.05	.47	.45	2	.07
19								
20								
21								
22								
23								
24								
25	.69	0.72	3	.07	.62	0.69	7	.03
26								
27	.72 (1)	0.69	3	.07	.65	0.67	2	.02
28	(.72) .57	.68	4 11	.06	~~.78~~ ~~.65~~ .63	.66	3	.02
29								
30								
oct 1								
2								
3								
4	.64	.59	5	.02	.62	.60	2	.01
5								
6								
7								
8	.61	.54	7	.01	.60	.57	3	.03
9								
10								
11	.54	.50	4	.00	.54	.54	0	.04
12								
13								
14								
15	.51	.44	7	.02	.49	0.50	1	.06
16								
17								
18								
19								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

(1) Trial polar

20								
21								
22								
23	0.33	0.33	0	.01	.32	.33	1	0
24								
25	0.29	.30	1	.01	.30	.30	0	0
26								
27								
28								
29								
30								
31								
Nov 1								
2								
3								
4								
5	.12	0.17	5	.08	.04	.07	3	.10
6								
7								
8								
9								
10								
11	0.07	0.07	0	.05	.02	59.97	5	.10
12								
13								
14	59.95	0.05	10	.04	59.91	.96	5	.09
15								
16	0.08	0.03	5	.01	0.07	.95	12	.08
17								
18	59.92	0.02	10	.07	59.85	59.94	9	.08
19								
20								
21		0.00						
22								
23								
24								
25								
26								
27	(0.22)[x]	0.17	5					
28								
29	(0.31)	0.31	0	.20	.11	.08	3	.23
30								

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( ) single folio

Dec 1								
2								
3								
4	0.34	.31	.03	.23	.12	.15	3	.16
5								
6								
7								
8	0.23	0.31	~~0.2~~ .08					
9	0.24	0.31	.07	00	.24	.22	2.	.19
10								
11								
12								
13	0.35	0.31	.04	.18	.17	.17	6	.14
14								
15								
16								
17								
18								
19	0.15	0.12	.03	.12	.03	0.03	0	.09
20								
21								
22								
23								
24	59.79	59.89	.10	.10	.69	59.79	10	.10
25								
26								
27								
28								
29								
30								
31	59.56	59.56	0	.10	.46	.46	0	.10

	e				A			
	T.C error	Plotted error P.E.	Erratis	(A-a) error	T.C error	Plotted error P.E	Erratis	$P.E_e - P.E_A$
Jan 0								
1								
2								
3	.25	.31	6	.05	.20	.20	0	.11
4								
5								
6	59.97	59.98	1	.05	59.92	59.92	0	.06
7								
8	59.50	59.52	2	.02	59.48	59.48	0	.04
9	59.30	59.29	1	.05	59.25	.25	0	.04
10								
11								
12	59.79	59.73	6	.07	59.72	~~.82~~ .72	0 ~~19~~	.01
13								
14								
15								
16								
17								
18	1.09	1.09	0	.02	1.07	1.09	~~8~~ 0	.02
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
Feb 1								
2								
3	0.97	.97	0	.05	0.92	.83	4	.14
4	~~.50~~							
5	.55	.69	14	.06	.49	.55	6	.07
6	.35	.54	9	.04	.34	.42	3	.12
7								
8	.01	.26	.25	.02	59.99	.10	11	.16
9								
10	59.83	59.98	15	.05	59.78	.79	0	.19

12	59.63	59.62	1	6 .04	59.59	.50	9	.09
13	59.57	59.52	5	2 .05	59.52			
14	59.64	Temps		.04	59.60			
15	59.79	changing		.04	59.75			
16								
17								
18								
19	0.32	.32	0	.05	.27	0.30		3 .02
20								
21								
22	.57	.53	4	.00	.57	.50	7	.03
23								
24								
25								
26	0.80	.80	0	.07	.73	.73	0	.07
27						0.80		
28	0.80	.75	5	.07	.73	.75		2 .00
March 1								
2								
3	.68	.66	2	.01	.67	.65	2	
4								
5								
6								
7								
8	.52	.53		1 .05	.47	.47	0	.06
9	.50	.50	0	.02	.48	.45	3	.05
10								
11								
12								
13	.35	.34	1	.07	.28	.29		1 .05
14	.39	.30	9	~~4~~ .05	.34	.27	7	.03
15	.35	.25	10	.14	.21	.21	0	.04
16								
17	.17	.17	0	.02	.15	.14	1	.03
18								
19	-0.07	-.09		2 .01	0.08	.07	1	.02
20	0.04	-.05		1 .02	.06	.03	3	.02
21								
22								
23								
24	59.86	59.88		2 .06	59.80	59.87		9 .01
25								

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Date								
26	59.76	59.80	4	.04	59.80	.80	0	0
27								
28								
29	59.70	59.68	2	.02	59.68	.66	2	.02
30	59.63	59.63	0	.04	59.59	.59	0	.04
31								
April 1								
2								
3								
4								
5	69.28	59.22	6	.05	59.33	.30	3	.08
6								
7								
8								
9	58.89	58.94	5	.11	59.00	59.10	10	.16
10	58.95	58.96	1	.14	59.09	.11	2	.15
11								
12	59.00	59.00	0	.07	59.07	.12	5	.12
13								
14	59.08	59.03	5	.06	59.14	.14	0	.11
15								
16	59.14	59.07	7	.05	59.19	.16	3	.19
17								
18								
19	59.16	59.11	5	.01	59.17	.19	2	.08
20								
21								
22								
23								
24	59.18	.22	4	~~.05~~ .07	59.25	.24	1	.02
25								
26	59.44	.34	10	.01 .07	59.43	.38	5	.04
27	59.44	.40	4	0 .04	59.48	.45	3	.05
28								
29								
30	59.65	.58	7	.04	59.61	.62	1	.04
May 1								
2	59.75	.74	1	.01	59.76	.76	0	.02
3	.80	.80	0	.02	59.82	.82	0	.02
4	.87	.86	1	.01	59.88	.88	0	.02
5	.93	.92	1	.02	59.95	59.95	0	.03
6								

* unadopted observation – rejected

7								
8								
9								
10								
11								
12								
13								
14								
15	.94	.94	0	.02	.92	0.92	0	.02
16								
17								
18								
19								
20								
21								
22	.26	.16	10	.13	.13	.09	4	.07
23	.16	0.05	11	.12	.14	59.99	15	.06
24	0.04	59.93	11	.12	59.92	.88	4	.05
25								
26	59.81	59.71	10	.13	59.68	.67	1 0	.04
27								
28	59.46	59.48	2	.05	59.41	.41	0	.07
29								
30	59.44	59.46	2	.05	59.39	.39	0	.07
31								
June 1	59.44	59.40	4	.11	59.33	.36	3	.04
2								
3								
4	59.35	59.34	1	.11	59.24	.30	6	.04
5	59.30	59.34	4	.08	59.22	.28	6	.06
6								
7	59.36	59.33	3	.13	59.23	.24	1	.09
8	59.29	59.33	4	.04	59.25	.23	2	.10
9								
10								
11								
12	59.25	59.32	7	.16	59.09	59.16	7	.16
13								
14	59.30	59.31	1	.07	59.23	.20	3	.11
15								
16	59.34	59.30	4	.08	59.26	.25	1	.05
17								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

18										
19										
20										
21										
22	59.49	59.46	3		.07	59.42	59.40	2		.06
23	59.49	59.49	0		.08	59.41	59.40	1		.09
24										
25	59.46	59.48		2	.14	59.32	.38		6	.10
26	59.57	59.47	10		.17	59.40	.37	3		.10
27	59.47	59.47	0		.12	59.35	36		1	.11
28										
29	59.44	59.46		2	.12	59.32	59.33		1	.13
30										
July 1										
2	59.52	59.55		3	.11	59.41	.41	0		.14
3										
4										
5										
6										
7	59.73	59.71	2		.15	59.58	.57	1		.14
8										
9	59.73	59.77		4	.14	59.59	.62		3	.15
10										
11										
12										
13										
14	59.96	59.92	4		.15	59.81	.78	3		.14
15										
16	59.97	0.02		5	.17	59.80	59.82		2	.20
17										
18										
19										
20	0.19	.22		3	.11	0.08	.08	0		.14
21	0.23	.28	5	5	.07	.16	.13	3		.15
22										
23										
24										
25										
26										
27										
28										
29										

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30	0.74	.74	0	.10	0.64	0.64	0	.10
31								
Aug 1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16	.64			.04	.60			
17	.68			.02	.66			
18								
19								
20								
21								
22	.94	1.00	6	.13	.81			
23	.93	.94	1	.06	.87	0.84	0	.07
24	.81	.88	7	.05	~~.86~~ .76	.83	7	.05
25								
26								
27								
28								
29	.56	.58	2	.07	.49	.50	1	.08
30								
31								
Sept 1	.37	.40	3	.07	.30	.31	1	.09
2								
3	.26	.28	2	.11	.15	.21	6	.07
4								
5	.13	.16	3	.04	.09	.09	0	.07
6								
7								
8	59.97	59.98	1	.07	59.90	.90	0	.08
9								

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10								
11	59.82	59.80	2	.07	59.75	59.73	2	.07
12								
13	59.70	59.68	2	.07	59.63	.63	0	.05
14								
15	59.64	59.56	8	.11	59.53	59.53	0	.03
16								
17								
18								
19	59.73	59.78		5 .04	59.69	.69	0	.09
20	59.81	59.84		3 .10	59.71	.73		2 .11
21								
22	59.98	59.95	3	.14	59.84	.80		4 .15
23								
24	59.98	0.06	~~2~~	8 .13	59.85	0.81		2 .19
25								
26	0.17	0.17	0	.08	.09	.09	0	.08
27								
28	.37	.38		1 .10	.27	30		3 .08
29								
30								
Oct 1								
2								
3	0.87	.86	1	.07	.80	0.80	0	.06
4						0.90		
5	1.89	0.85	4	.10 .09	.79	.80		1 .05
6	.81	.75	6	.10 .09	~~.81~~ 7	.70	1	.05
7								
8								
9	.59	.44	15	.11	.48	.40		8 .04
10								
11								
12	.20	.14	6	.12	.08	.10		2 .04
13	0.09	.04	5	.11	59.98	.00		2 .04
14								
15								
16	59.76	59.74	2	.14	59.62	.70		8 .04
17								
18	59.51	59.53	~~2~~	2 .12	59.39	59.50		11 .03
19								
20								
21								

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22	59.55	59.55	0	.08	59.47	.50	3	.05
23								
24								
25								
26								
27	59.57	59.57	0	.08	59.49	59.50	1	.07
28								
29	59.70	59.65	5	.11	59.59	.58	1	.07
30								
31	59.77	59.73	4	.10	59.67	.66	1	.07
Nov 1								
2								
3								
4								
5								
6								
7	.02	0.02	0	.14	59.88	59.90		.12
8								
9	R	Opened to replace fused wire						
10								
11								
12								
13								
14	.11	0.13	2	.15	59.96			
15								
16	0.04	.0.01	3	.10	59.94			
17								
18								
19	0.02	59.83	19	.12	59.90	59.90	0	.07
20								
21								
22	59.75	59.66	9	.13	59.62	.64	8 2	.08
23								
24								
25								
26								
27	59.36	59.36	0	.11	59.25	.30	59	.02
28								
29								
30								
~~31~~								
Dec 1	59.18	59.24	6	.11	59.07	59.06	1	.18

Day								
3	59.12	59.12	0	.15	58.97	58.96	1	.16
7	59.07	59.09	2	.19	58.88	.95	7	.14
10	59.12	59.06	6	.19	58.93	.94	1	.12
14	59.02	59.04	2	.18	58.84	.93	9	.11
17	59.05	59.04	1	.12	58.93	.92	1	.12
20	59.09	59.03	6	.12	58.97	.91	6	.12
22	59.14	59.03	11	.22	58.92	.91	4	.12
27	59.07	59.03	4	.14	58.93	.90	3	.13

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27th	T.C. error	Plotted Error (e)	Erratis	(A-a) error ep	T.C. error	Plotted error (A)	Erratis	$P.E_e - P.E_A$
March 24								
25								
26								
27	58.62	58.62	.00	01	58.61	58.60	1	.02
28								
29	58.82	58.82	0	.04	58.78	.79	1	.05
30	59.02	58.92	10	.14	58.88	.88	0	.04
31	59.10	59.02	8	.09 10	59.00	58.98	2	.04
April 1								
2	.20	.21	1	10 ~~.09~~	59.10	.18	8	.03
3								
4	.44	.41	3	.08	59.36	36	0	.05
5	.52	.51	1	~~.07~~ .01	59.53	.46	7	.05
6	.63	.61	2	.06 .01	59.57	.55	2	.06
7	59.78	59.71	7	.05	59.73	.65	8	.06
8								
9								
10								
11								
12								
13	0.35	0.30	5	.10	0.25	.23	2	.07
14	.43	.40	3	.11	.32	0.32	0	.08
15	.43	.50	7	.06	.37	.39	2	.11
16								
17								
18								
19								
20								
21								
22	.96	.96	0	.05	.91	0.91	0	.05
23								
24								
25								
26	1.20	1.11	09	.07	1.13	.08	5	.03
27	1.18	1.15	3	.04	1.14	1.12	2	.03
28	1.18	1.18	0	.05	1.13	1.15	2	.03
29								
30								
May 1								
2	0.80	.78	2	.12	.68	.68	0	.10
3								
4								

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5								
6								
7								
8								
9								
10	59.96	59.85	11	12	59.8~~6~~4	59.75	9	.10
11								
12								
13	59.87	59.85	2	.14	59.73	.75	2	.10
14								
15	59.78	59.85	7	.06	59.72	.74	2	.11
16	59.82	59.85	3	.17	59.65	.74	9	.11
17								
18	59.80	59.85	5	.60	59.70	.73	3	.12
19	~~59.80~~							
20	59.80	59.85	5	.06	59.74	.73	1	.12
21								
22	59.86	59.86	0	.06	59.80	.72	8	.14
23								
24								
25								
26	59.90	59.86	4	.13	59.77	.71	6	.15
27								
28								
29	59.82	.86	4	.12	59.70	.71	1	.15
30	59.86	.86	0	.14	59.~~82~~72	.70	2	.16
31								
June 1	59.85	.81	4	.17	59.68	.70	2	.11
2								
3	59.84	.76	8.	.14	59.70	59.70	0	.16
4								
5								
6	59.78	.68	10	.17	59.61	.61	0	.07
7								
8								
9								
10								
11								
12								
13	59.47	.51	4	.13	59.34	.35	1	.16
14								
15	59.46	.46	0	.15	59.31	.30	1	.16

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16	59.43	59.43	0	.13	59.30	.29	1	.14
17	59.41	59.41	0	.14	59.27	.27	0	.14
18								
19	59.24	59.36	8	.11	59.13	.23	10	.13
20	59.34	59.33	1	.13	59.21	.20	1	.13
21	59.32	59.31	1	.14	59.18	.19	1	.12
22								
23								
24								
25								
26								
27								
28								
29	59.18	59.21	3	.12	59.06	59.06	0	.15
30	59.25	59.25		.12	59.13	.10	3	.15
July 1								
2								
3	59.34	59.35	1	.14	59.20	.20	0	.15
4								
5								
6								
7								
8								
9								
10								
11								
12	59.66	59.67	1	.13	59.53	.50	3	.17
13								
14	59.69	59.74	5	.11	59.58	.58	0	.16
15								
16								
17	59.81	59.84	3	.14	59.67	.77	10	.07
18								
19	59.88	59.91	3	.04	59.84	59.84	0	.07
20								
21	59.99	59.99	0	.07	59.92	59.93	1	.06
22	0.06	0.06	0	.06	00	59.98	2	.08
23								
24	0.25	.21	4	.13	.12	.12	0	.09
25	0.27	.28	1	.11	.16	.19	3	.09
26	0.33	.36	3	.07	.26	.26	0	.10
27								

28	0.48	.51	3	.08	0.40	.40	0	.11
29								
30								
31	.73	.73	0	.14	.59	.65	6	.08
Aug 1	.79	.81	2	.05	.74	.74	0	.07
2								
3	0.96	.96	0	.07	.89	0.89	0	.07
4								
5								
6								
7	0.54	.50	4	.12	.42	.42	0	.08
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20	59.01	59.01	0	.10	58.91	58.91	0	.10
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
Sept 1	59.68	59.68	0	.06	59.62	59.62	0	.06
2	.57	59.58	1	.14	59.43	.46	3	.12
3								
4	59.34	59.39	5	.14	59.20	.18	2	.21
5								
6	59.17	59.19	2	.18	58.99	58.90	9	.29
7								

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8	59.03	59.00	3		.12	58.~~85~~ .91	58.91	0		.09
9	59.06	.12		6	.06	59.00	.00	0		.12
10	A									
11										
12	59.47	.48		1	.13	59.34	.34	0		.14
13										
14										
15	59.83	59.84		1	.13	59.~~60~~ 70	.70	6		.14
16										
17										
18										
19										
20	0.43	0.44		1	.16	0.27	0.27	0		.17
21										
22										
23	0.82	0.80	2		.19	0.63	0.63	0		.17
24										
25	1.03	1.03	0		.16	0.87	0.87	0		.16
26										
27										
28	0.74	.63	11		.12	0.62	0.62	0		.01
29										
30	0.42	.36	6		.08	.34	.34	0		.02
Oct 1										
2	0.15	.10	5		.08	0.07	07	0		.03
3	0.08	59.97	11		.16	59.92	.92	0		.05
4										
5										
6										
7	59.42	.43		1	.10	59.32	.40	8		.03
8										
9	59.17	59.17	0		.07	59.10	59.08	2		.09
10										
11	59.30	59.33		3	.07	59.23	.23		1	.10
12	59.36	59.41		6	.10	59.25	.30		5	.11
13										
14	59.49	.57		8	.00	59.49	.49	0		.08
15										
16	59.78	.73	5		.13	59.65	.63	2		.10
17										
18	59.93	.89	4		.11	59.82	.80	2		.09
19	6.03	59.97	6		.07	59.96	.88	8		.09

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20	0.06	0.05	1	.01	0.05	.98	7	.07
21	0.14	.13	1	.04	.10	.03	7	.10
22								
23								
24	0.36	.37	1	.10	.26	.27	1	.10
25	0.40	.45	5	.04	.36	37	1	.08
26	.49	.53	4	.05	.44	.44	0	.09
27								
28								
29								
30								
31	0.92	0.92	0	.10	.82	0.83	1	.09
Nov 1	.79.	.73	6	.06	.73	.68	5	.05
2	~~0.43~~	~~.36~~	~~7~~	~~.08~~	~~.35~~			
3	0.43	.36	7	.08	.35	.33	2	.03
4								
5								
6	59.81	59.80	1	.10	59.71	.75	4	.05
7								
8	59.43	59.43	0	.06	59.37	59.38	1	.05
9								
10								
11								
12								
13								
14	59.72	.79	7	.04	59.68	.68	0	.11
15	59.82	59.85	3	.10	59.72	.73	1	.12
16								
17								
18								
19								
20								
21	0.06	0.21	15	.10	59.96	.03	4	.18
22								
23								
24								
25								
26								
27								
28								
29								
30	.78	0.75	3	.01	.79	0.79	0	.04

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Dec 1	.81	.81	0	.06	.75	.70	#5	.11
2								
3								
4	0.43	.44	1	.02	.41	.39	2	.05
5								
6								
7								
8	59.97	59.94	3	.01	59.98	.93	5	.01
9								
10								
11								
12								
13								
14	59.20	59.20	0	.02 .01	59.21	59.25	4	.05
15								
16	59.49	59.45	4	.02	59.47	.45	2	0
17								
18								
19	59.79	59.82	3	.04	59.78	.80	2	.02
20								
21								
22	0.23	.21	2	.06	0.17	.17	6	.04
23	.34	.32	2	.02	.32	.29	3	.03
24								
25								
26	.69	.69	0	.02	.67	.62	5	.07
27		0.94						
28						0.82		
29	.82	.83	1	.04	.78	.78	0	.05
30	0.71	.72	1	.01	.70	.70	0	.02
31								

	ℓ				A			
	T.C error	Plotted error	Errati	(H-a) error ε	T.C error	Plotted error	Errati	P.E ℓ - P.E A
Jan 0	59.35	59.35	~~59.3~~0					
1								
2	59.30	.40	10					
3								
4	.54	.45		.12	.42	59.36	6	
5	.48	.485	3	.07	.41	.38	3	.07
6	.49	.486	3	.08	.41	40	1	.06
7	.59	.48, ~~.50~~	11	.10	.49	.42	7	.06
8	.58	.50	8	.10	.48	.44	4	.06
9	.44	.52	8	.01	.43	.46	3	.06
10								
11	.58	.56	2	.08	.50	50	0	.06
12								
13								
14	.60	.62	2	.06	.54	54	0	.08
15	.60	.64	4	.07	.53	56	3	.08
16	.71	.65	6	.13	.58	58	0	.07
17								
18	.68	.69	1	.08	.60	.61	1	.08
19								
20	.65	.73	8	.01	.64	.64	0	.09
21	.71	.75	4	.08	.53	.66	3	.09
22	.81	59.77	4	.10	.71	.68	3	.09
23								
24								
25								
26	.83	59.84	1	.04	.79	59.76	3	.08
27						.76		
28						.76		
29								
30								
31								
Feb 1								
2	.90	.83	7	.07	.83	.75	8	.08
3						.74		
4								
5								
6								
7								
8	.89	.81	8	.10	.79	.73	6	.08
9	.89	.81	8	.13	.76	.72	4	.09
10								

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11								
12	.79	.81	2	.07	59.72	.72	0	.09
13								
14								
15								
16								
17	.81	.80	1	.06	59.75	.71	4	.09
18	.81	.79	2	.07	59.74	.71	3	.08
19								
20								
21								
22	.75	.79	4	.08	.67	.70	3	.09
23	.77	.78	1	.07	.70	.70	0	.08
24	.80	.78	2	.17	.63	.69	6	.09
25	.77	.78	1	.08	.69	.69	0	.09
26								
27	.77	.78	1	.06	.71	.69	2	.09
28								
Jul, 29	59.95	59.77	2	.06	.69	.68	1	.09
2 30								
3	.78	.74	1	.16	.62	.68	6	.09
4								
5	.75	.77	2	.07	.68	.67	1	.10
6								
7	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~	~~[illegible]~~			
8	~~.92~~ .74	~~.80~~ 59.77	~~12~~ 0	~~.17~~ .09	~~.75~~ .68	59.67	1	.10
9	.92	.80	12	.17	.75	.71	4	.09
10								
11								
12	.92	.88	4	.10	.82	.82	6	.06
13	59.91	.91	0	.07	84	.85	1	.06
14								
15	0.00	59.97	3	.06	.94	59.94	0	.03
16								
17								
18	.01	0.05	4	.08	.93	.95	2	.10
19								
20	.10	.11	1	.12	59.98	.98	0	.13
21								
22	.14	.16	2	.15	59.99	0.00	1	.16
23								
24								

25						0.00		
26	.14	.14	0	.14	0.00	59.98	2	16
27	0.09	.09	0	.17	59.92	.95	3	14
28								
29	59.91	0.01	10	.06	59.85	.90	5	11
30	.92	59.97	5	.10	.82	.87	5	.10
31	.90	.93	3	.06	.84	.84	0	.09
April 1	.89	.88	1	.10	.79	.81	2	.07
2								
3	.80	.80	0	.10	.70	.74	4	.06
4								
5	.75	59.72	3	.06	.69	.68	1	.04
6								
7	.76	.74	2	.10	.66	.69	3	.05
8	.76	.76	0	.07	.69	.69	0	.07
9	.76	.77	1	.08	.68	.70	2	.07
10								
11								
12	.78	.80	2	.10	.68	.71	3	.09
13	.82	.82	0	.10	.72	.72	0	.10
14								
15	.89	.84	5	.12	.77	.73	4	.11
16	.85	.85	0	.10	.75	.73	2	.12
17	59.87	59.86	1	.17	.70	.74	4	.12
18								
19								
20	.94	.90	4	.17	.77	.75	2	.15
21								
22	.93	59.93	6	.20	.73	.75	2	.18
23								
24								
25								
26								
27	.79	.84	5	.01	.78	.78	0	.06
28	.77	.82	5	.04	.73	.76	3	.06
29	.78	.80	2	.10	.68	.74	4	.06
30								
May 1								
2								
3	.69	.73	4	.06	.63	.65	2	.08
4								
5								

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6	.68	.68	0	.10	.58	.61	3	.07
7								
8								
9								
10	.55	.60	5	.01	.54	.54	0	.06
11								
12	.62	59.58	4	.07	.55	.50	5	.08
13								
14								
15	.58	~~.58~~ .55	3	.19	.39	59.44	5	.11
16								
17	.60	~~.58~~ .54	6	.13	.47	.45	2	.09
18								
19								
20	.57	59.52	5	.10	.47	.46	1	.06
* 21	.41	.51	10	.05	~~.37~~ .46	.47	1	.04
22	.49	59.49	0	.00	.49	.47	2	.02
23								
24	.54	.53	1	.06	.48	.48	0	.05
25								
26								
27	.63	.59	4	.18	.45	.49	4	.10
28								
29								
30								
31	.68	59.68	0	.16	52	.51	1	.17
June 1	.63	.68	5	.06	.57	52	5	.16
2								
3	.67	.68	1	.17	.50	.53	3	.15
4								
5	.66	.67	1	.13	.53	.53	0	.14
6								
7	.68	.67	1	.14	.54	59.54	0	.13
8	.67	59.67	0	.17	.50	.50	0	.17
9								
10	.58	.59	1	.14	.44	43	1	.16
11	.56	.56	0	.20	.36	39	3	.17
12	59.52	.52	0	.10	.42	.35	7	.17
13								
14	59.49	.44	5	.16	.33	.27	6	.17
15	.43	.46	3	.17	.26	.23	3	.17
16	.37	.37	0	.13	.24	.19	5	.18

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17	.37	.33	4	.19	.18	.14	1	.18
18								
19	.19	59.25	6	.12	.07	.08	1	.17
20								
21	.25	.25	0	.20	'05	.08	3	.17
22								
23								
24								
25								
26								
27								
28	.28	.25	3	.15	.13	.11	2	.14
29								
30								
ly 1	.30	.26	4	.17	.13	.11	2	.15
2								
3								
4								
5	.30	.26	4	.17	.13	.12	1	.14
6								
7								
8								
9	.26	.26	0	.14	.12	.12	0	.14
10	.33	.39	6	.12	.21	.24	3	.15
11								
12								
x 13	.78	.77	1	.11	.67	.60	7	.17
x 14	59.89	59.90	1	.07	.82	.72	10	.18
x 15	0.09	0.02	7	.19	.90	.85	5	.17
16								
17	.15	.14	1	.06	09	0.09	0	.05
18								
19								
20								
21								
22	.12	.11	1	.07	.05	.03	2	.08
23	.10	.10	0	.10	0	.02	2	.08
24	.12	.10	2	.11	.01	.01	0	.09
25								
26	.12	.08	4	.13	59.99	.99	0	.09
27								
x28	.08	'07	1	.16	59.92	.96	4	.11

29	.04	.07	3	11	59.93	.96	2	.12
30	.07	.06	1	14	59.88	93	5	.13
31								
y 1								
2								
3								
4								
5								
6	.02	.02	0	13	59.89	.85	4	.17
7	59.99	.01	2	15	59.84	.84	0	.17
8								
9								
10	.93	59.94	1	14	59.79	.79	6	.15
11								
12	.89	.89	0	11	59.78	.76	2	.13
13	59.82	.87	5	07	59.75	.74	1	.13
14	59.85	59.85	0	13	59.72	.73	1	.12
15								
16								
17								
18	.03	0.03	0	.20	59.83	.83	0	.20
19	.07	0.03	4	.21	.86	86	0	.17
20	.08	.04	4	.19	.89	.89	0	.15
21								
22								
23	.06	.06	0	.18	88	.88	0	.18
24								
25	.09	.07	2	.18	.91	.89	2	.18
26	.08	.08	0	.20	88	.90	2	.18
27	.13	.09	4	.20	.93	.90	3	.19
28								
29								
30	.17	.11	6	12	0.05 reject *			
31								
y 1								
2								
3	.14	.14	0	.27	59.~~8~~ 87	.93	6	.21
4	.16	.14	2	.24	92	.93	1	.21
5								
6								
7	.14	.16	2	.21	93	.94	1	.22
8	.16	.16	0	.22	.94	.94	0	.22

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* C assumed. 3 clock stars one polar. Observation poor

9								
10	.10	.10	0	.20	59.90	.90	0	.20
11	.06	.08	2	.16	.90	.88	2	.20
12								
13	.02	0.02	0	.21	.81	59.83	2	.19
14								
15	.05	.06	1	.23	82	.86	4	.20
16								
17								
18								
19								
20	.21	.15	6	.23	59.98	.96	2	.19
21	.16	.16	0	.21	599 5	.97	2	.19
22	.19	.18	1	.22	599 7	59.98	1	.20
23								
24		(.29)						
25	.14							
26			0	.19				
27	.07	.07	0	.19	59.88	.88	0	.19
28	.10	.10	0 6	.26	59.84	.85	1	.25
29	.06	.12	6	.26	59.80	82	2	.30
30	.12	.15	7 3	.21	599 1	.87	4	.26
Oct 1	.20	.18	2	.30	59.90	.89	1	.29
2	.21	.21	0	.28	599 3	.93	0	.28
3								
4	.31	.26	5	.30	0 1	.98	3	.28
5	.34	.29	5	.31	.03	.01	2	.28
6	.32	.31	1	.29	.03	.02	1	.29
7	.37	.34	3	.30	.07	.06	1	.28
8								
9								
10		(.42)						
11	.41	.40	1	.24	.17	.18	1	.22
12								
13	.31	.36	5	.26	.05	.12	7	.24
14	.35	.34	1	.27	.08	.09	1	.25
15	.39	.32	7	.29	.10	.07	3	.25
16	.34	.30	4	.30	.04	.04	0	.26
17								
18								
19								
20								

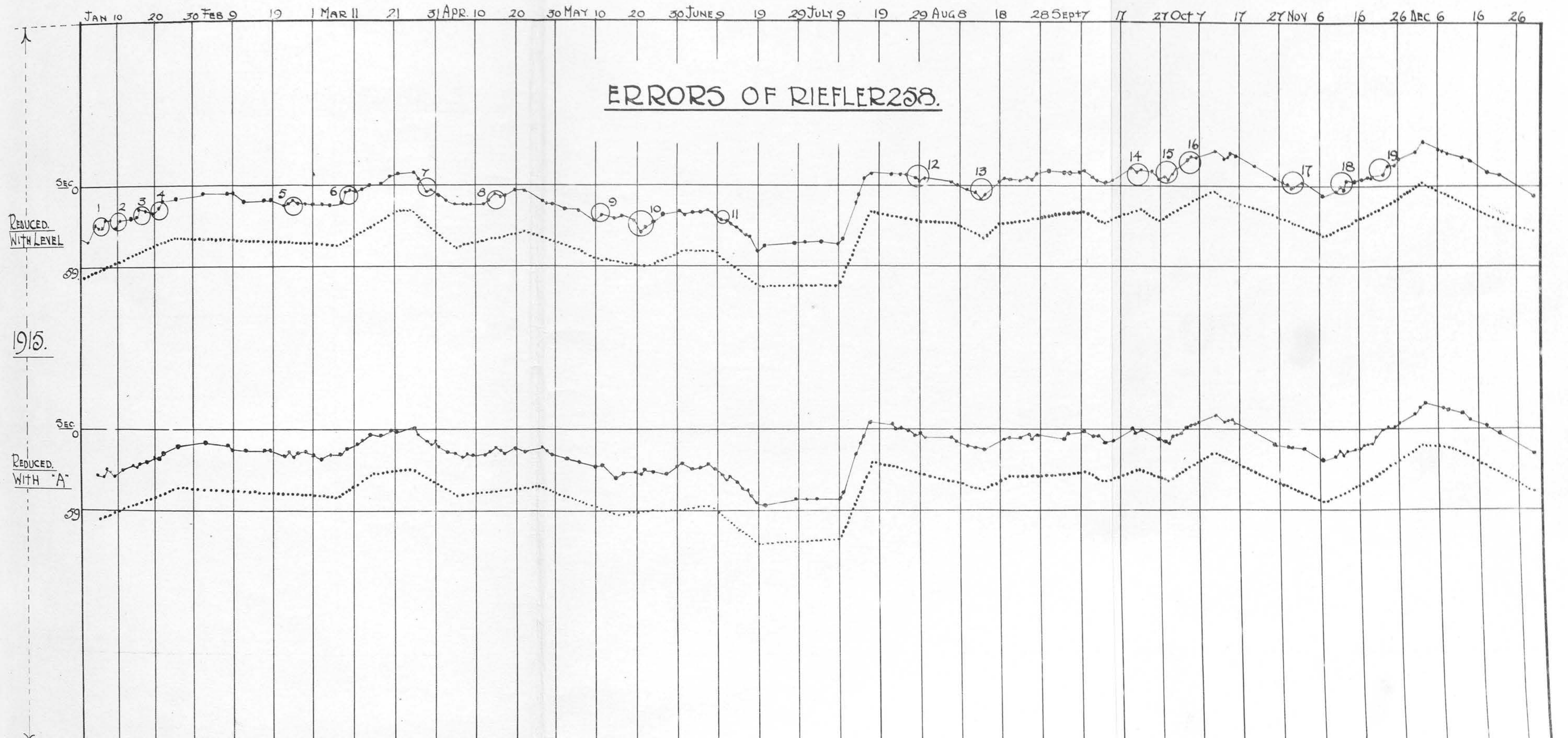
(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

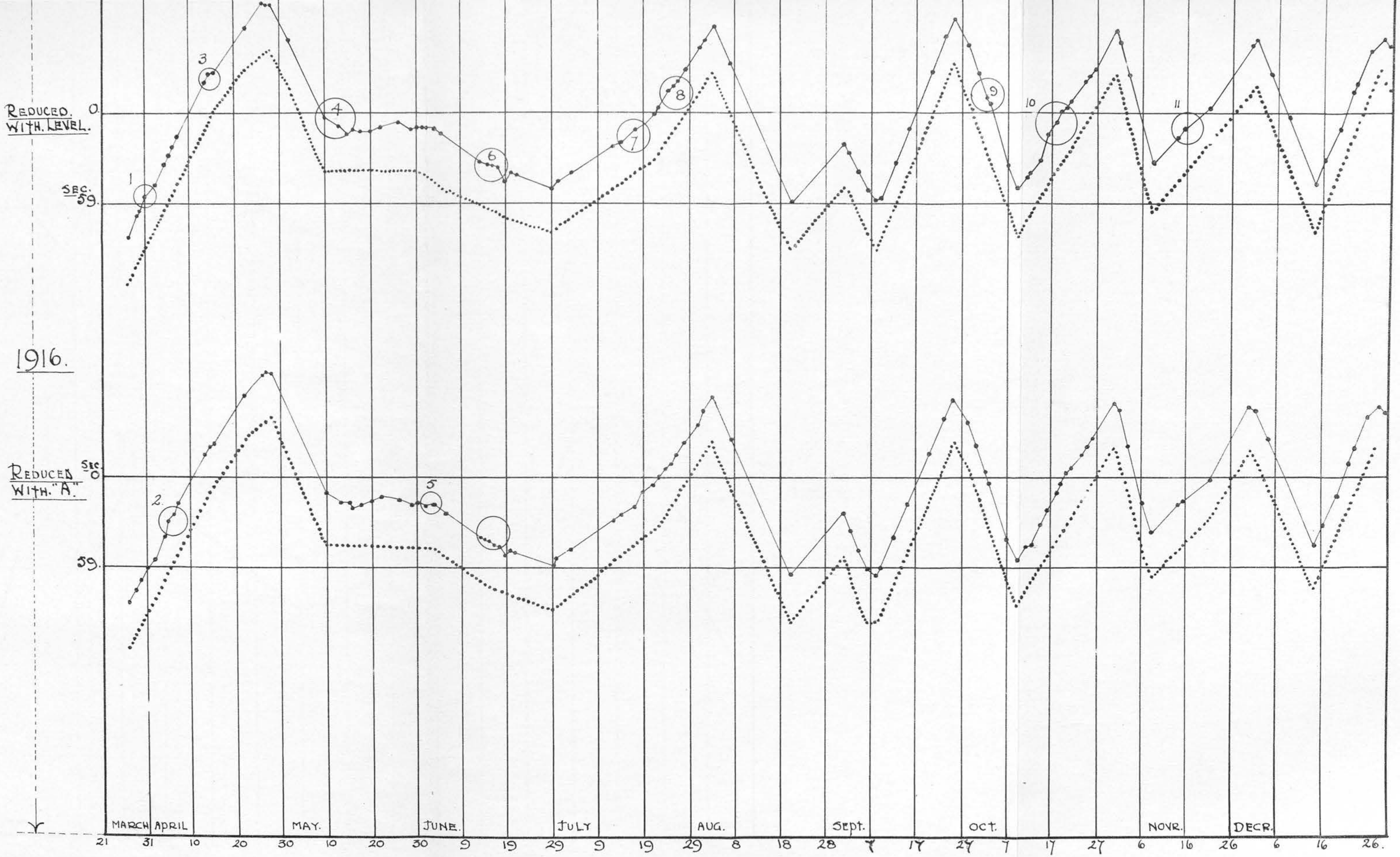
21	.22	.20	2	.29	59.93	.94	2	26
22								
23								
24								
25								
26	.05	.10	5	.28	59.77	.84	7	.26
27								
28								
29	.00	.04	4	.25	.75	.77	2	.27
30	59.96	.02	6	.22	.74	.74	0	.28
31								
Nov 1								
2	0.02	59.98	4	.29	.73	.67	6	.31
3								
4								
5								
6								
7	59.85	59.85	0	.28	.57	59.56	1	.29
8								
9								
10	59.91	.92	1	.30	.61	.61	0	.31
11	.97	.95	2	.29	.68	.64	4	.31
12	.92	.97	5	.29	.63	.67	4	.30
13	0.03	59.99	4	.35	68	.70	2	29
14								
15	0.02	0.04	2	.32	.70	.74	4	.30
16	.08	.07	1	.37	.87	.77	6	.30
17	.06	.09	3	.29	.77	.79	2	.30
18	.09	.11	2	.31	.78	.81	3	.30
19	.08	.14	6	.30	.78	.84	6	.30
20	.11	.16	5	.24	.87	.87	0	.29
21	.~~11~~							
22	~~.23~~ .16	.21	5	.19	.97	.94	3	.27
23	.23	.23	0	.25	.98	.97	1	.26
24								
25	.23	.28	5	.24	.99	.03	6	.25
26	.31	.31	0	.29	.02	.06	4	.25
27								
28								
29								
30	.41	.46	5	.25	.16	.21	5	.25
Dec 1								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14

2	.53	0.53	0	.24	.29	.27	2	.28
3								
4								
5								
6	.45	0.43	2	.19	.26	.25	1	.18
7	.42	.41	1	.18	.24	.24	0	.17
8	.40	.39	1	.18	.22	.23	1	.16
9								
10								
11								
12	.35	.29	6	.18	.17	.18	1	.11
13								
14	.30	.24	6	.21	.09	.12	3	.12
15								
16								
17								
18	.17	.15	2	.16	.01	.01	0	.14
19								
20								
21	0.12	.07	5	.20	59.92	.92	0	.15
22								
23								
24								
25								
26								
27								
28								
29								
30	59.85	59.85	0	.17	59.68	59.68	0	.17
31								

(677) Wt 6035-54 10m 2/16 M & G Ltd G 14


ERRORS OF RIEFLER 258.
JAN 10 20 30 FEB 9 19 1 MAR 11 21 31 APR. 10 20 30 MAY 10 20 30 JUNE 9 19 29 JULY 9 19 29 AUG 8 18 28 SEPT 7 17 27 OCT 7 17 27 NOV 6 16 26 DEC 6 16 26
REDUCED. WITH LEVEL
1915.
REDUCED. WITH "A"
SEC 0
59



REDUCED. WITH. LEVEL.
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SEC. 59.
1916.
REDUCED WITH. "A."
SEC. 0
59.
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MARCH
APRIL
MAY.
JUNE.
JULY
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OCT.
NOVR.
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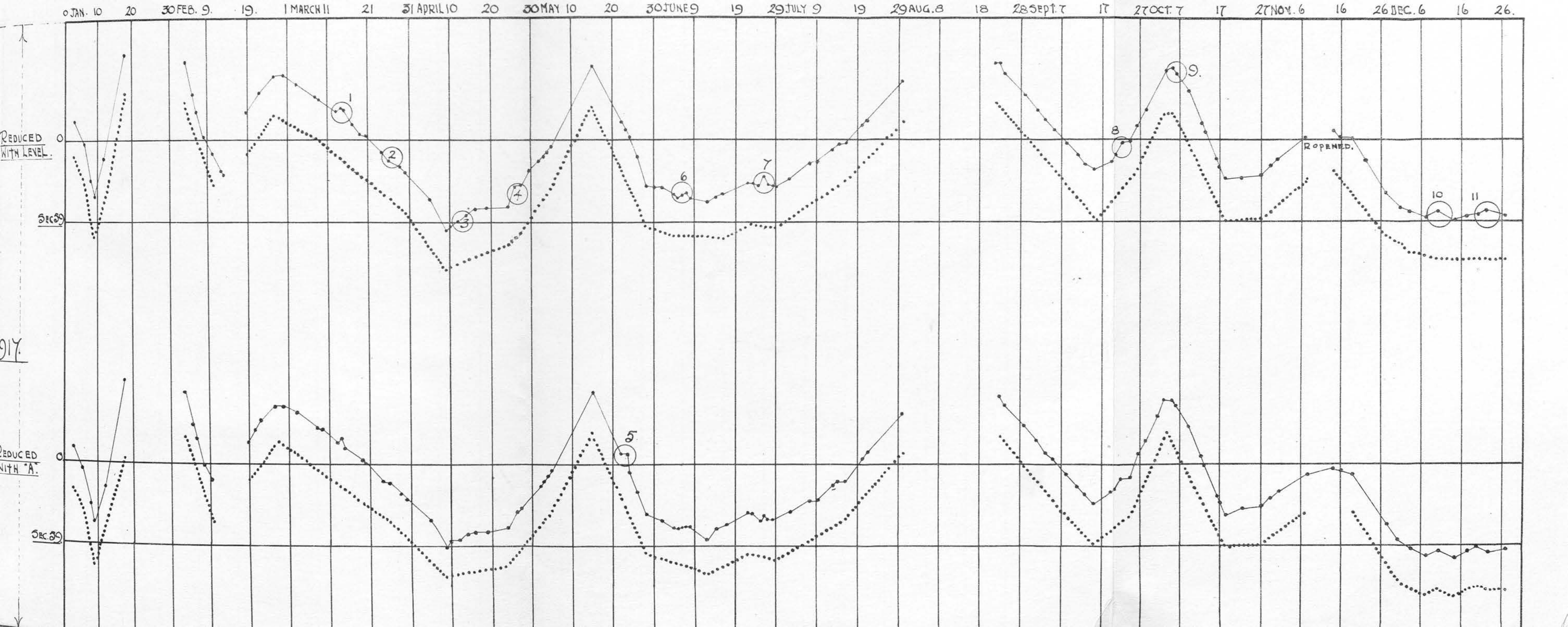

0 JAN. 10 20 30 FEB. 9 19 1 MARCH 11 21 31 APRIL 10 20 30 MAY 10 20 30 JUNE 9 19 29 JULY 9 19 29 AUG. 8 18 28 SEPT. 7 17 27 OCT. 7 17 27 NOV. 6 16 26 DEC. 6 16 26.
REDUCED WITH LEVEL.
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SEC. 39
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ROPENED.
917.
REDUCED WITH "A".
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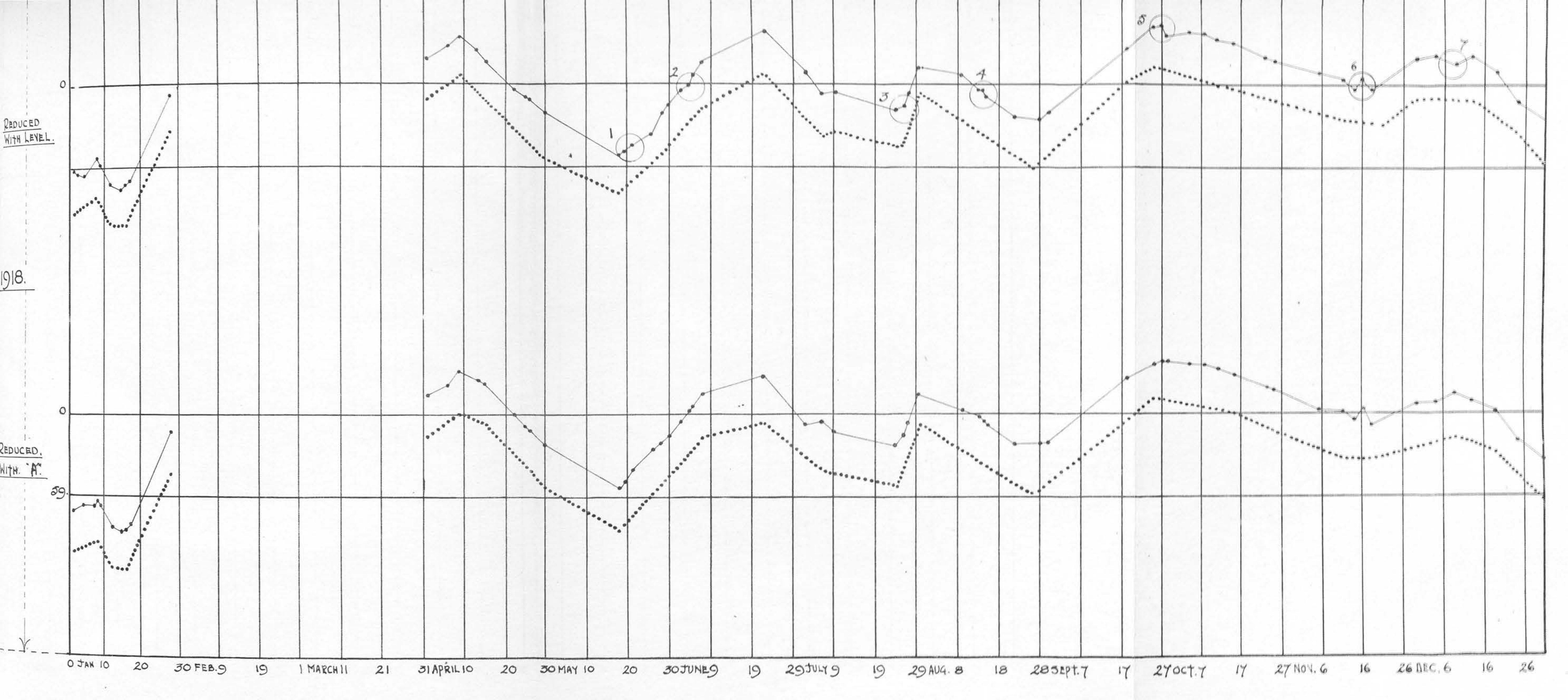
SEC. 39



1918.
REDUCED WITH LEVEL.
REDUCED. WITH. "A".
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1
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0 JAN 10
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30 FEB. 9
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31 APRIL 10
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30 MAY 10
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30 JUNE 9
19
29 JULY 9
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29 AUG. 8
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28 SEPT. 7
17
27 OCT. 7
17
27 NOV. 6
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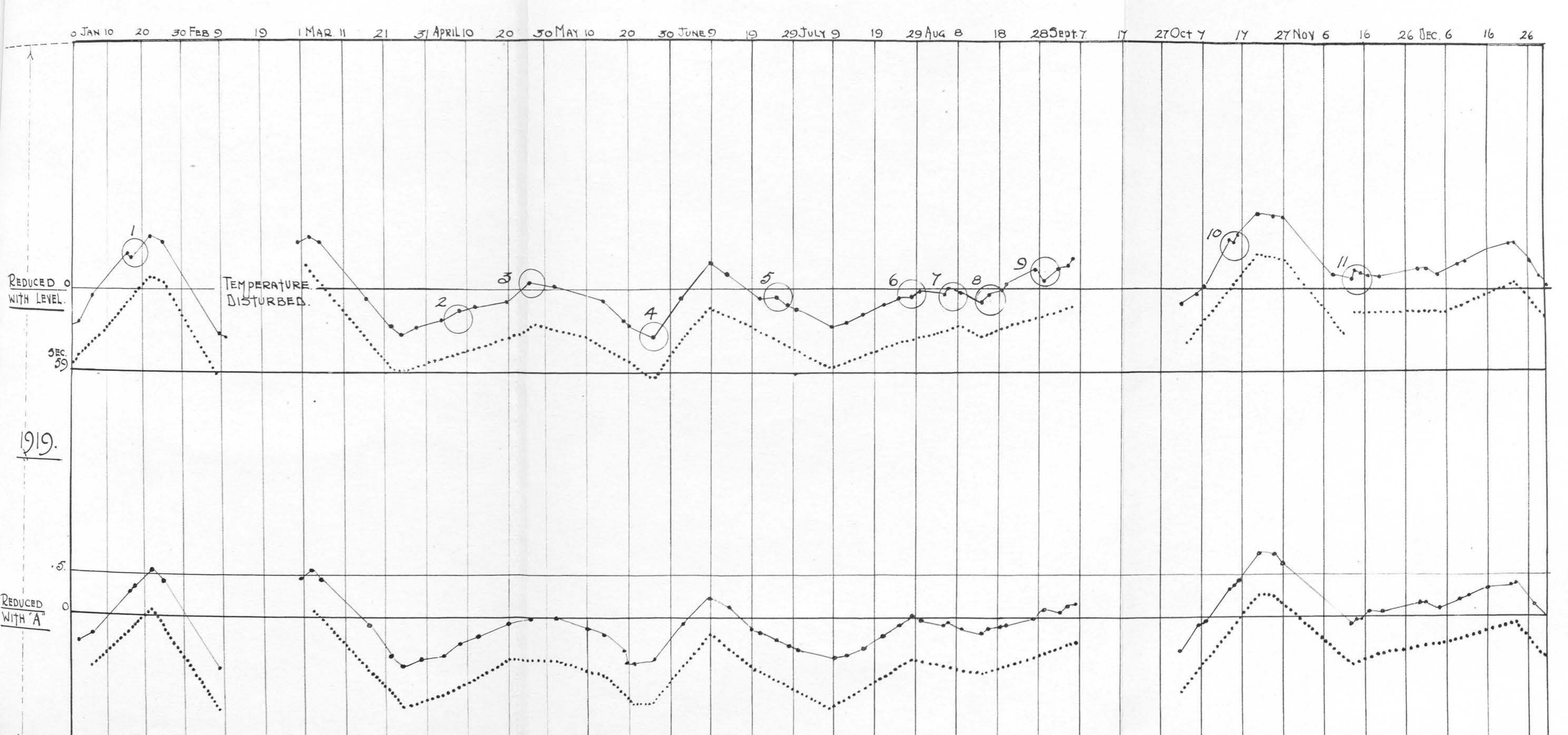
26 DEC. 6
16
26



0 JAN 10 20 30 FEB 9 19 1 MAR 11 21 31 APRIL 10 20 30 MAY 10 20 30 JUNE 9 19 29 JULY 9 19 29 AUG 8 18 28 Sept. 7 17 27 Oct 7 17 27 NOV 6 16 26 DEC. 6 16 26
REDUCED WITH LEVEL.
REDUCED WITH "A"
0
SEC. 59
.5
TEMPERATURE DISTURBED.
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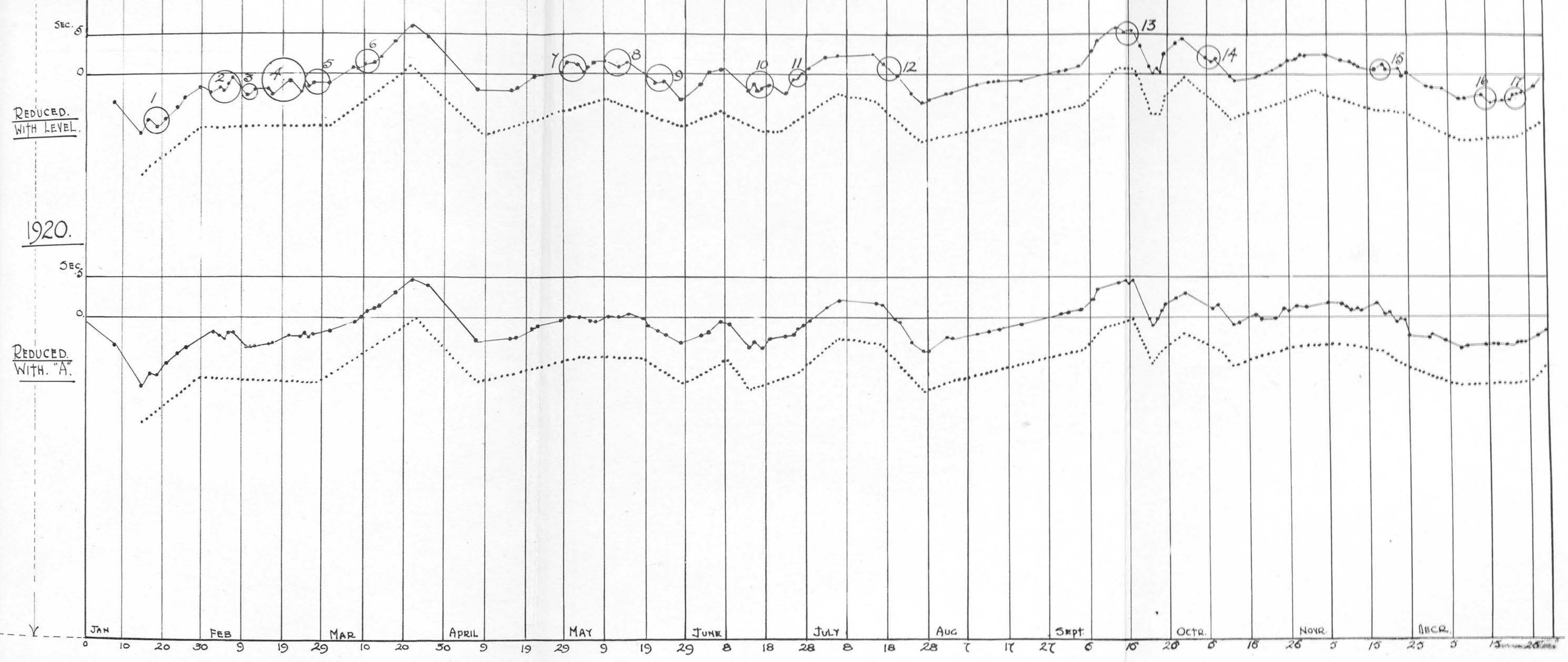
1919.



Sec. .5
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Reduced. With Level.
1920.
Sec. .5
0.
Reduced. With. "A".
Jan
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April
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June
July
Aug
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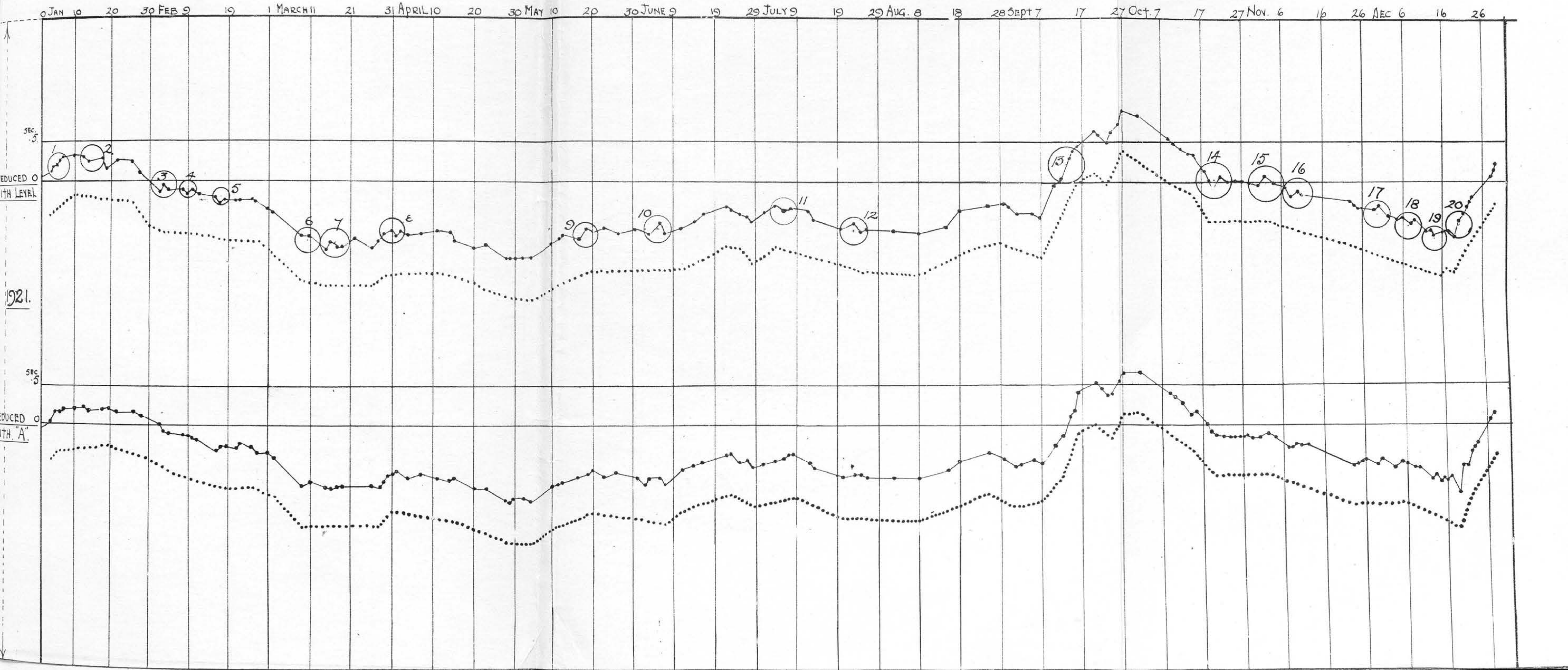
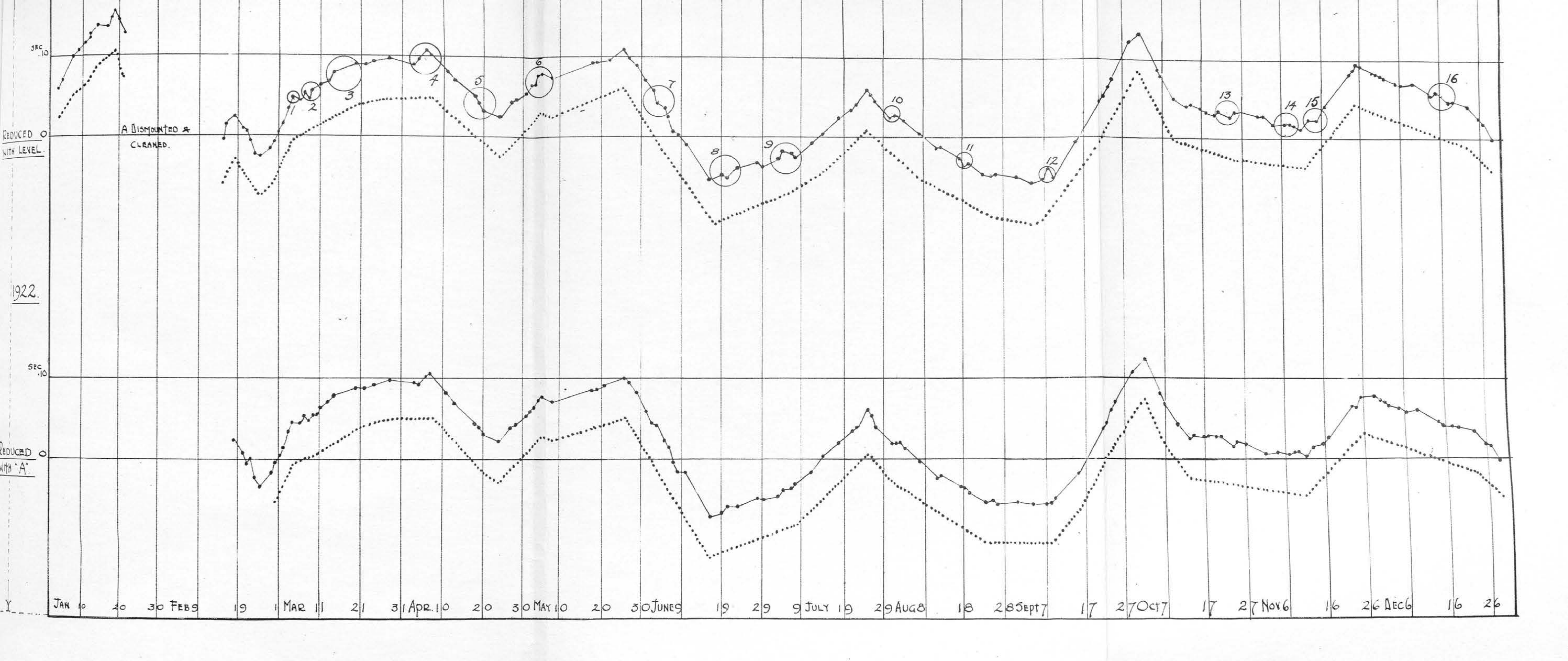
Octr.
Novr.
Decr.
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
0 10 20 30 9 19 29 10 20 30 9 19 29 9 19 29 8 18 28 8 18 28 7 17 27 6 16 26 6 16 26 5 15 25 5 15 25

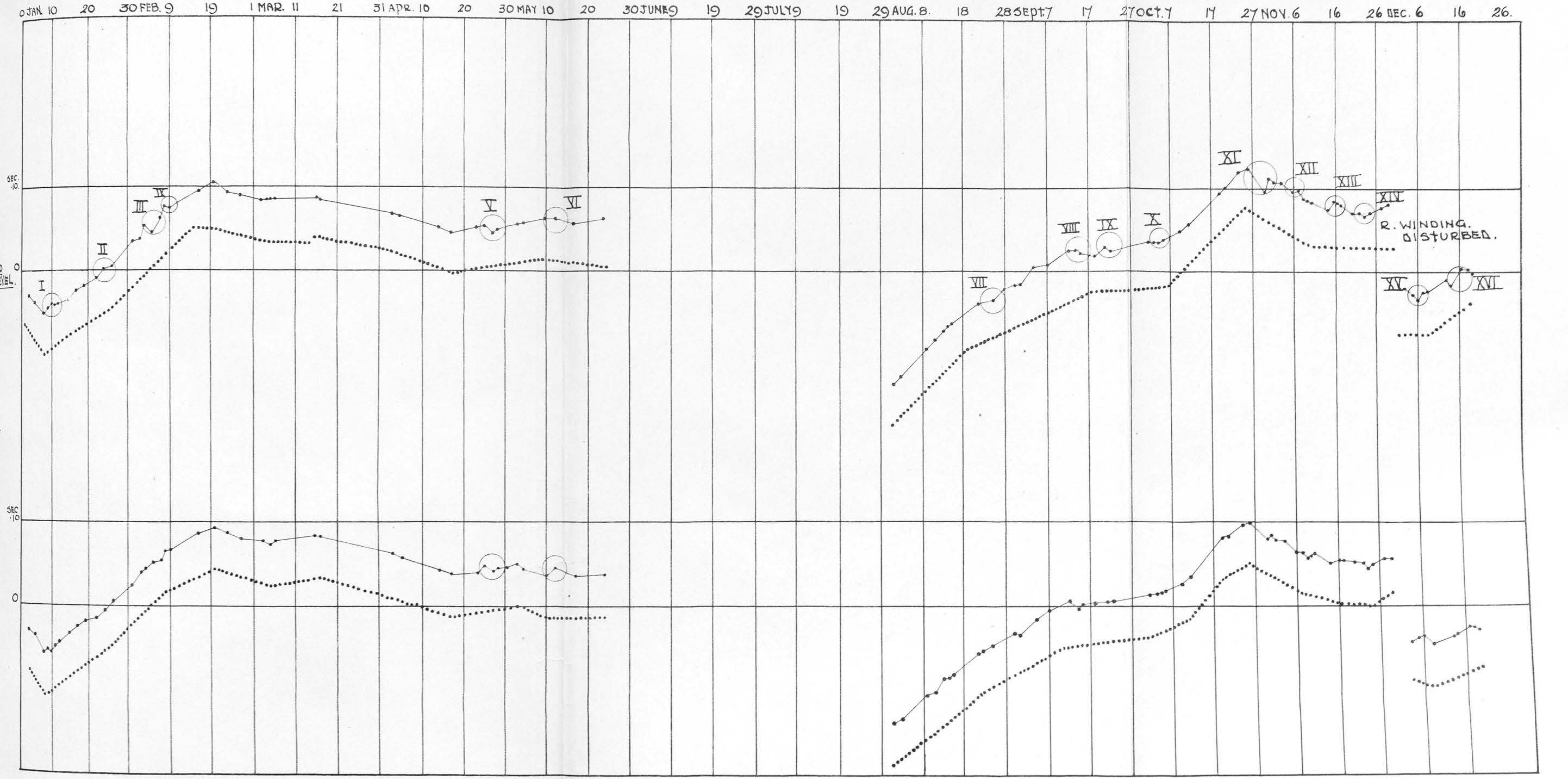
M. R. Madwar



0 JAN 10 20 30 FEB 9 19 1 MARCH 11 21 31 APRIL 10 20 30 MAY 10 20 30 JUNE 9 19 29 JULY 9 19 29 AUG. 8 18 28 SEPT 7 17 27 OCT. 7 17 27 NOV. 6 16 26 DEC 6 16 26
SEC. ·5
EDUCED 0
ITH LEVEL
1921.
SEC. ·5
EDUCED 0
ITH. "A".
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20



SEC. .10
REDUCED 0
WITH LEVEL.
A DISMOUNTED & CLEANED.
1922.
SEC. .10
REDUCED 0
WITH "A".
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
JAN 10 20 30 FEB 9 19 1 MAR 11 21 31 APR. 10 20 30 MAY 10 20 30 JUNE 9 19 29 9 JULY 19 29 AUG 8 18 28 SEPT 7 17 27 OCT 7 17 27 NOV 6 16 26 DEC 6 16 26


0 JAN. 10 20 30 FEB. 9 19 1 MAR. 11 21 31 APR. 10 20 30 MAY 10 20 30 JUNE 9 19 29 JULY 9 19 29 AUG. 8. 18 28 SEPT. 7 17 27 OCT. 7 17 27 NOV. 6 16 26 DEC. 6 16 26.
SEC. ·10.
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SEC. ·10
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I
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III
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VII
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IX
X
XI
XII
XIII
XIV
XV
XVI
R. WINDING. DISTURBED.

Th. Sect.

ON THE CAUSE OF ANOMALOUS DETERMINATION OF TIME. By M. R. MADWAR, B.Sc.

Monthly Notices of R.A.S., Jan. 1926.

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ON THE CAUSE OF ANOMALOUS DETERMINATION OF TIME.

BY

M. R. MADWAR, B.Sc.

(*Communicated by Professor R. A. Sampson, F.R.S.*)

In *M.N.*, **82**, 221, Professor R. A. Sampson showed that the irregu-ties in the trace of the clock correction could neither be ascribed the chronographic system nor to a diurnal fluctuation in the clock e, but are, as a rule, due to our adopted instrumental constants. se are the well-known quantities c, m, n, as used in Mayer's formula. The procedure at the Royal Observatory, Edinburgh, included, ides these, the determination of the quantities A and $[a]$; where A otes the azimuth of the transit circle east of the South collimator $[a]$ the azimuth of the North collimator.

It was also shown in *M.N.*, **85**, 560, that the elimination of the level r and the introduction of A in the time reduction was responsible the disappearance of a great number of the above-mentioned gularities or erratics in the trace of the errors of the clock (Shortt 4) during 1924. With a view to explore this method further errors of Riefler 258, from 1915 January to 1923 December, have been computed by both methods of reduction. The charts attache show the traces of the observed (full line) and adopted (dotted line clock errors on a time basis. It will be readily seen that a great numbe of erratics resulting from the ordinary method of reduction are elimi nated, some are only reduced, and the reduction with A and n introduce elsewhere erratics smaller in number and in variation.

The mean erratic during the nine selected years is reduced from ±·03 sec. to ±·02 sec. This in itself is a large reduction, for the latte includes all errors due to personality and those of an accidental natur pertaining to the instrumental constants, the chronographic system and all errors due to a lateral component in atmospheric refraction whether inside the telescope, in the transit-circle house, or outside and finally, those due to errors in the R.A. of stars. But apart from this reduction, the aim was to show that certain of the large erratic introduced by the ordinary method of reduction have been eliminated when the reduction is carried out with A and n. The azimuth A o the transit circle has been derived from an arbitrary zero (·397), and thus the clock errors are not absolute; however, we are more concerned with the variation of the clock errors than their absolute values, and th fixing of the datum line has no effect on the outcome.

The difference between the adopted clock error when the reduction is made with l and the adopted error when the reduction is made with A, n shows a seasonal variation which can only be due to either or to both methods of reduction. The following table shows the monthly mean of the above-mentioned difference for every year and for th nine selected years :—

	1915.	1916.	1917.	1918.	1919.	1920.	1921.	1922.	1923.	Mean.
	″	″	″	″	″	″	″	″	″	″
Jan.	·07	..	·05	·17	·09	·08	·05	..	·05	·080
Feb.	·09	..	..	..	..	·16	·00	..	·04	·073
Mar.	·11	..	·03	..	·10	·11	·04	·03	·07	·070
Apr.	·08	·05	·09	·01	·03	·07	·02	·02	·09	·051
May	·09	·12	·03	·03	·07	·11	·03	·06	·16	·078
June	·17	·14	·10	·03	·13	·13	·04	·11	..	·106
July	·12	·10	·14	·02	·01	·03	·05	·07	..	·068
Aug.	·16	·08	·07	·02	·11	·04	·06	·05	·15	·082
Sept.	·21	·12	·09	·04	..	·10	·11	·10	·16	·117
Oct.	·27	·08	·04	−·02	·15	·07	·11	·10	·20	·110
Nov.	·29	·07	..	·11	·16	·06	·13	·10	·24	·129
Dec.	·16	·03	·14	·13	·12	·08	·02	·06	·24	·120

The maxima and minima do not occur at the same time, but underg a slight shift from year to year. For the nine years selected the lowest value occurs in April and the highest value in November, the difference between them being ″·08. This discrepancy may be either due to the eliminated level error l or to the introduced quantity A; for both these quantities show seasonal variations. However, the South collimator appears to be fairly steady (*M.N.*, 75, 74), whereas the leve

aries sensibly from night to night and also shows seasonal varia-
ollowing the temperature of the eastern pier of the transit circle.
nce the method of time reduction with A and n has given a
l improvement in the trace of clock errors, it appears a probable
ption that the level error introduces a seasonal variation in the
d clock error. Also the comparison of wireless signals from
olis with the mean of six observatories shows a decided seasonal
n the time reduction of Washington (*M.N.*, 82, 219); and the
rison between Edinburgh and Annapolis shows an improvement in
sonal error when the reduction is carried with A, n instead of l.
level error is determined by means of a mercury bath and a
berger eyepiece, the movable wire of the telescope is made to
e with the reflected image of the middle wire, and the reading
micrometer gives a measure of the level error. This reading is
at the beginning and at the end of each observation; but as
rcury trough has to be removed during the observing period, the
dings form two independent determinations of the level error;
iffer very slightly, and this rules out of court any accidental
in the determination of l, but leaves untouched any errors that
ntered equally and with the same sign into both determinations.
the assumption that the earth's crust is insensible to the tidal
of sun and moon and to the effect of diurnal variation of tem-
re, we may form an upper limit of the errors contributed by these
which are tacitly and wrongly debited to the instrumental level
consequently reappear in the clock correction.
moon tide-generating potential at any point on the earth's
is the spherical harmonic

$$\frac{GM}{R^3} r^2 \frac{(3 \cos^2 z - 1)}{2} \qquad \frac{GM}{R^3} p^2 \frac{(3 \cos^2 z - 1)}{2}$$

M is the mass of the moon.
R, distance to the earth's centre.
r, radius of earth at the point considered.
G, gravitation constant.
z, angle between the line joining the earth and moon and the earth's radius.

horizontal and the vertical component of the tide-generating
:

$$F_h = -\frac{3}{2} \frac{GM}{R^3} r \sin 2z.$$

$$F_v = \frac{GM}{R^3} r (3 \cos^2 z - 1).$$

first force produces a deviation in the direction of gravity, and
ond alters its intensity; this deviation is

$$\frac{3}{2} \left(\frac{M}{M'}\right) \left(\frac{r}{R}\right)^3 \sin 2z = ''{\cdot}018 \sin 2z.$$

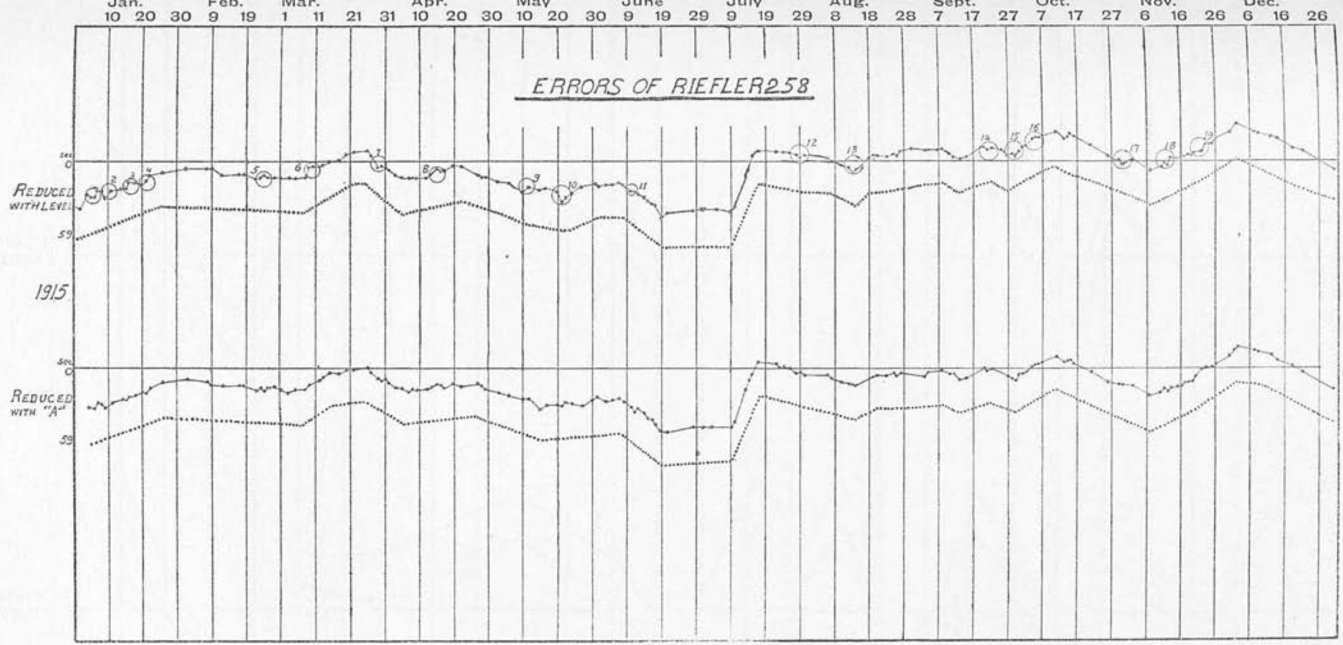
The sun's effect, owing to its remote distance and greater mass, produces a deviation $= ''\cdot 008 \sin 2z$, and will be additive when the moon is in opposition or conjunction, and subtractive when it is in quadratures.

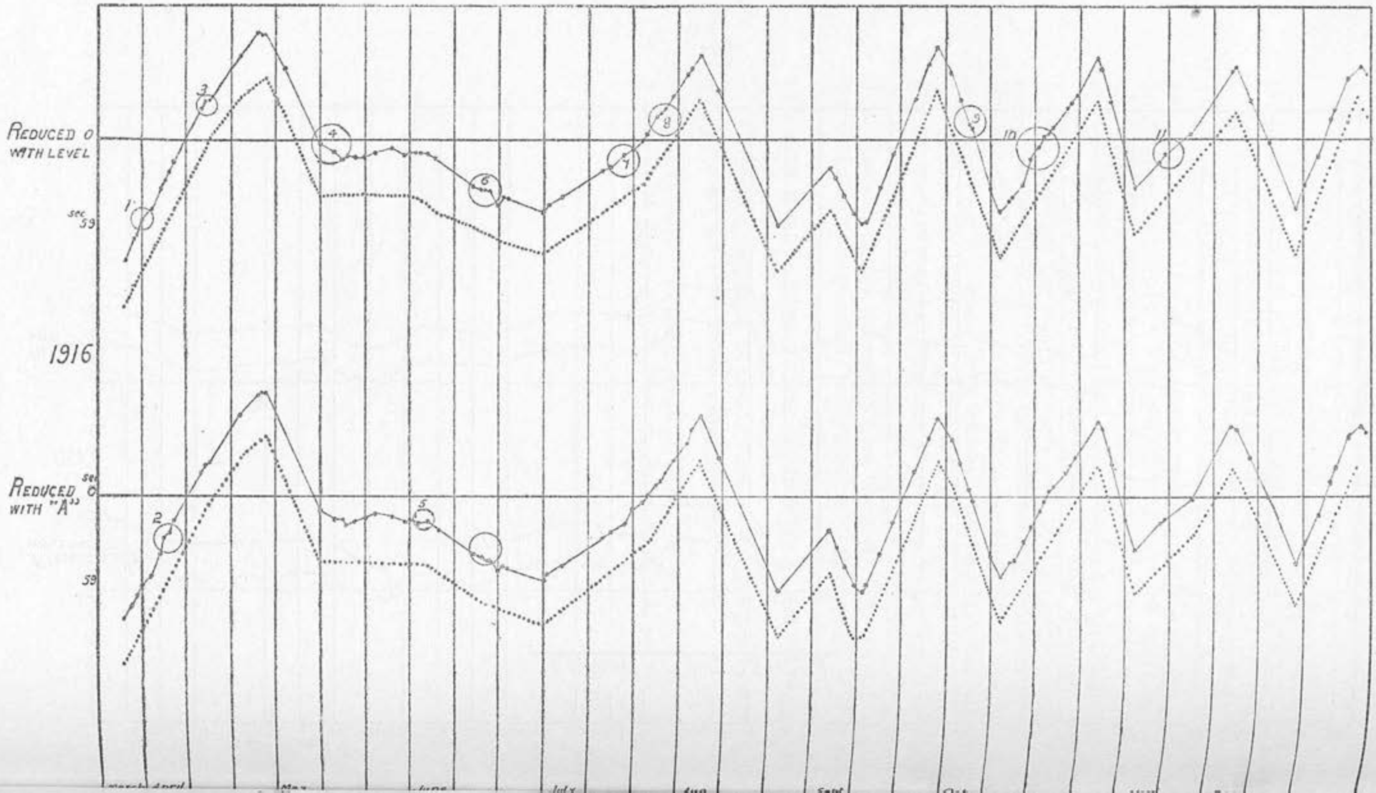
But the rising tide may produce on a plumb line near the coast a deviation equal to, if not greater than, that due to direct action of the sun and moon. An approximate calculation shows that this cannot be greater than $''\cdot 025$. This would make a total maximum deviation of $''\cdot 050$, which would be responsible for an erratic whose greatest value is $^{s}\cdot 006$ only; a very small and almost negligible quantity.

The diurnal variation in temperature may likewise produce different effects on the mercury bath and on the earth's crust, and this difference produces an error in the estimation of the instrumental level l; but the estimation of this error does not admit of a simple treatment, as in the previous case; only we may mention that the experiments of O. Hecker with the horizontal pendulum in 1907 * show that the mean diurnal variation of the direction of gravity is very small also, and does not produce an erratic feature in the time determination more than $^{s}\cdot 004$. It appears from this discussion that there is no theoretical error in the value of l, as determined by the process adopted, or that these theoretical errors are so very small that they could hardly account for the erratics; and yet a great number of these are smoothed away when the reduction is carried out without the level error.

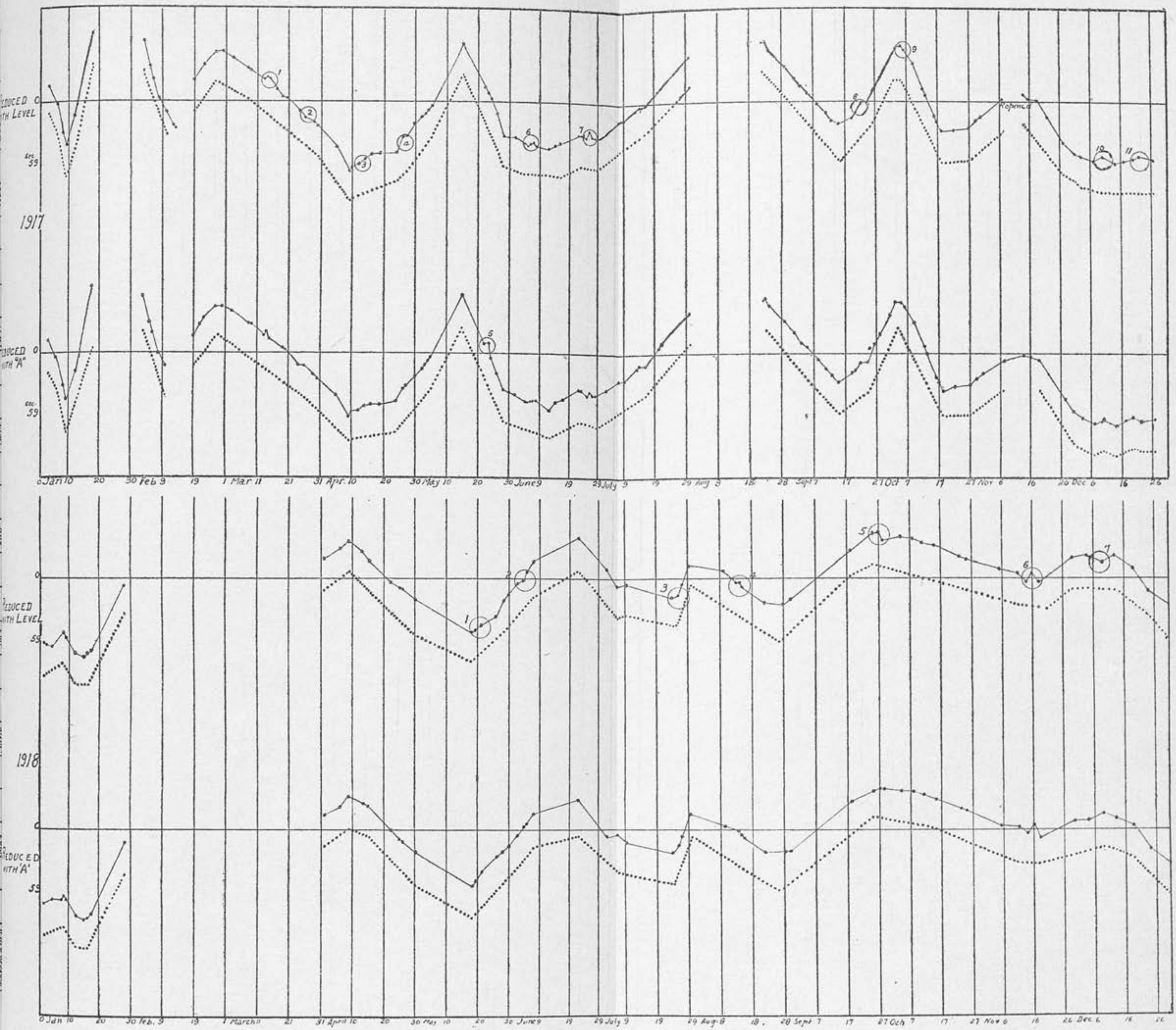
In conclusion I wish to express my deep gratitude to Professor R. A. Sampson for his kind interest and advice.

* O. Hecker, "Beobachtungen an Horizontalpendeln," *Veröff. d. Königl. preuzz. geodät. Inst.*, 1907; Lallemand, *Bulletin Astronomique*, **33**, 369, 1911.

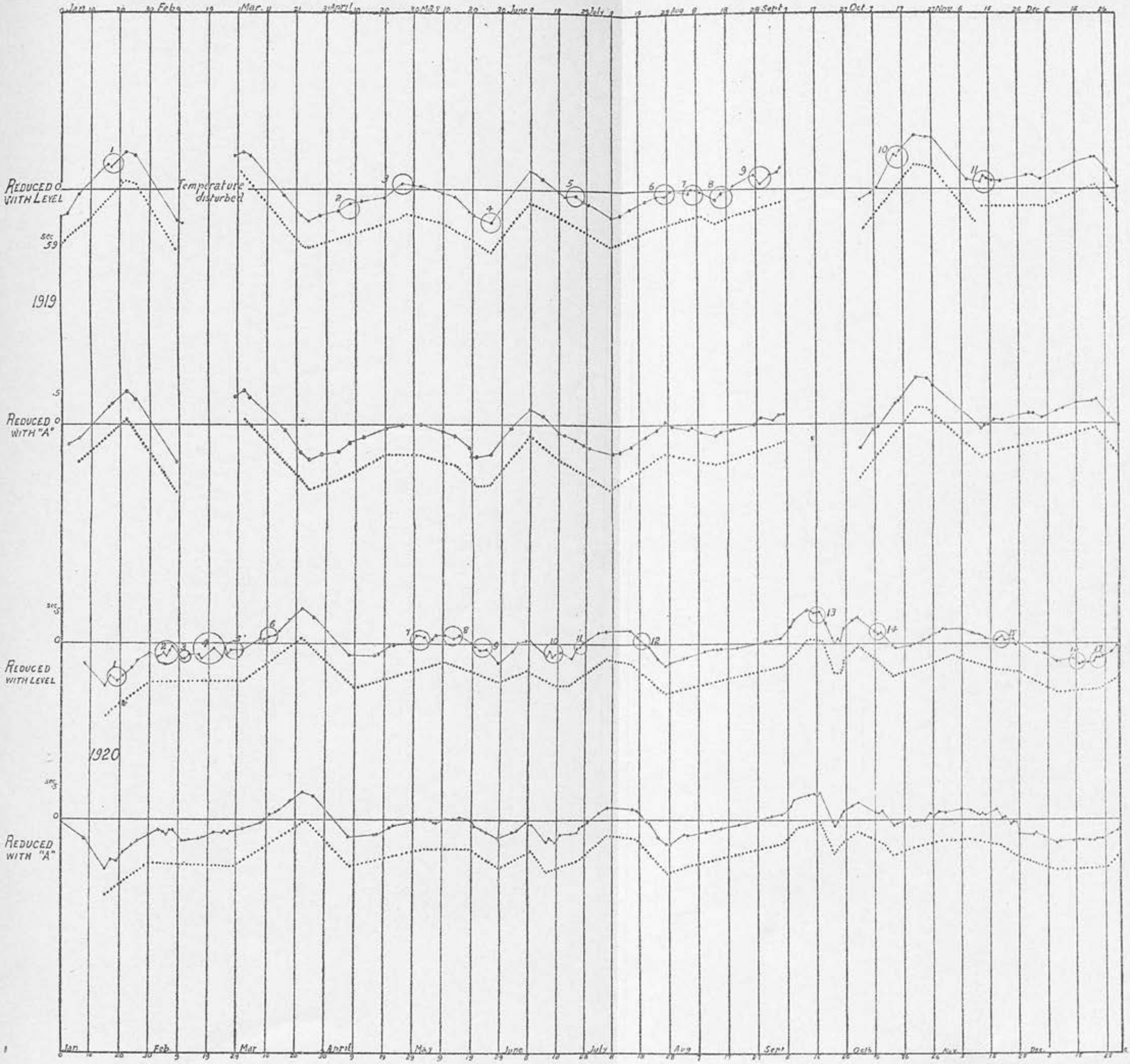

ERRORS OF RIEFLER 258
1915
Jan. 10 20 30 Feb. 9 19 Mar. 1 11 21 31 Apr. 10 20 30 May 10 20 30 June 9 19 29 July 9 19 29 Aug. 8 18 28 Sept. 7 17 27 Oct. 7 17 27 Nov. 6 16 26 Dec. 6 16 26
REDUCED WITH LEVEL
REDUCED WITH "A"
sec
0
59



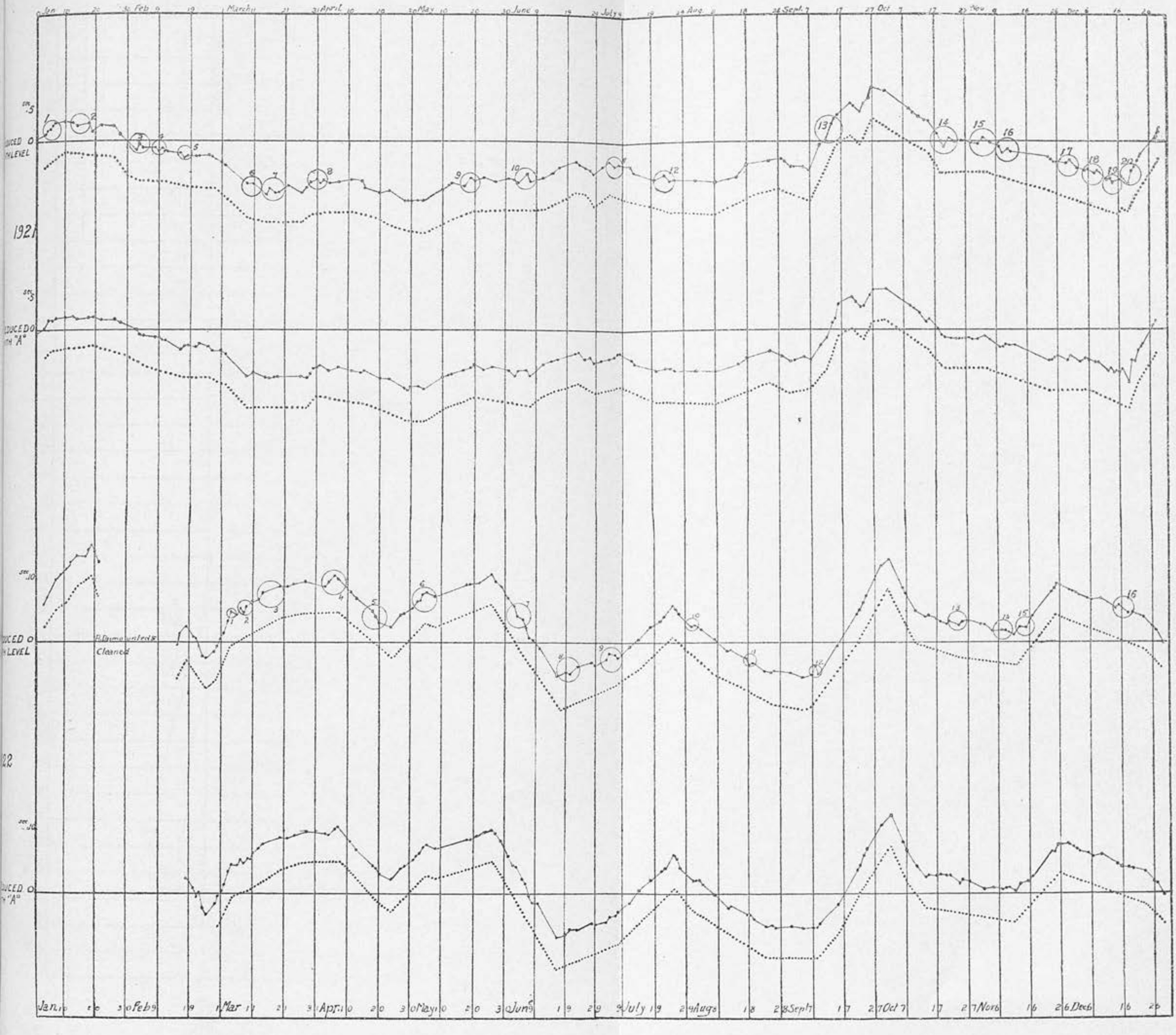
REDUCED 0
WITH LEVEL
sec 59
1916
REDUCED WITH "A"
sec 0
59



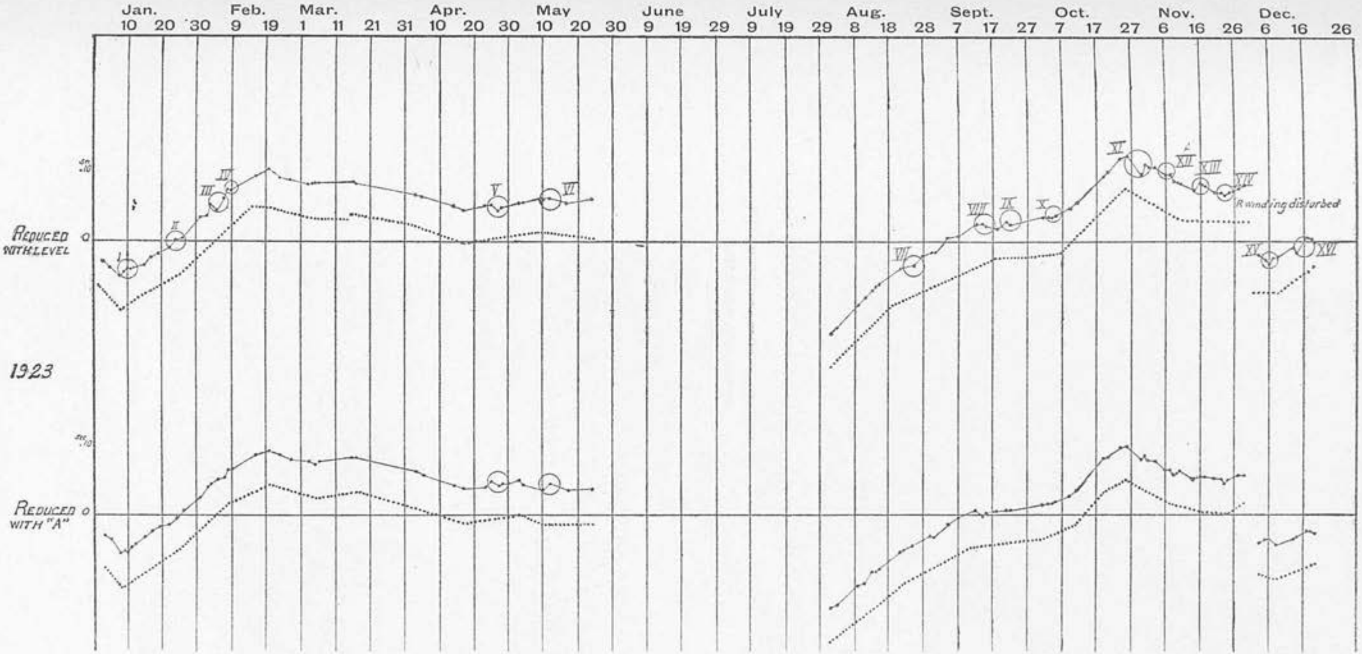
1917
1918
REDUCED WITH LEVEL
REDUCED WITH "A"
0
59
0 Jan 10 20 30 Feb 9 19 1 Mar 11 21 31 Apr. 10 20 30 May 10 20 30 June 9 19 29 July 9 19 29 Aug 8 18 28 Sept 7 17 27 Oct 7 17 27 Nov 6 16 26 Dec 6 16 26
0 Jan 10 20 30 Feb. 9 19 1 March 11 21 31 April 10 20 30 May 10 20 30 June 9 19 29 July 9 19 29 Aug. 8 18 28 Sept 7 17 27 Oct 7 17 27 Nov 6 16 26 Dec 6 16 26



REDUCED WITH LEVEL
Temperature disturbed
sec 59
1919
REDUCED WITH "A"
REDUCED WITH LEVEL
1920
REDUCED WITH "A"



1921
REDUCED 0 SEA LEVEL
REDUCED 0 WITH "A"
REDUCED 0 SEA LEVEL
REDUCED 0 WITH "A"
Pendulum Dismounted & Cleaned
Jan. 10 20 30 Feb 9 19 1 Mar 11 21 31 Apr. 10 20 30 May 10 20 30 June 9 19 29 9 July 19 29 Aug 8 18 28 Sept 7 17 27 Oct 7 17 27 Nov 6 16 26 Dec 6 16 26


Jan. 10 20 30
Feb. 9 19
Mar. 1 11 21 31
Apr. 10 20 30
May 10 20 30
June 9 19 29
July 9 19 29
Aug. 8 18 28
Sept. 7 17 27
Oct. 7 17 27
Nov. 6 16 26
Dec. 6 16 26
Reduced with level 0
1923
Reduced with "A" 0
I
II
III
IV
V
VI
VII
VIII
IX
X
XI
XII
XIII
XIV
XV
XVI
R winding disturbed

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